SCIENCE ABSTRACTS.

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PHYSICS AND ELECTRICAL ENGINEERING.

VOL. I.

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LIST OF JOURNALS.

In 1898 Abstracts were made from the following Journals. An asterisk (*) indicates that abstracts were only occasionally made from those so marked.

Abbreviations.	Full Title.
*Akad. Wiss. Cracow	Akademie der Wissenchaften, Cracow.
Amer. Acad. Proc	American Academy of Arts and Sciences, Proceedings.
Amer. Electn.	American Electrician.
Amer. Instit. Elect. Engin. Trans	American Institution of Electrical Engineers, Transactions.
Amer. Journ. Sci	American Journal of Science.
Ann. du Bureau des Longitudes	Annuaire pour l'an 1898 publié par le Bureau des Longitudes.
Annal. Chim. Phys	Annales de Chimie et de Physique.
Annal. Phys. Chem.	Annalen der Physik und Chemie.
Archiv Math. Phys.	Archiv der Mathematik und Physik, Leipzig.
Archiv. Post. Tele.	Archiv für Post und Telegraphie.
*Archives Néerlandaises	Archives Néerlandaises.
*Archives of the Röntgen Ray.	Archives of the Röntgen Ray.
*Assoc. Suisse Elect. Ann.	Association Suisse des Electriciens, Annuaire.
*Ast. Phys. Journ	Astro-Physical Journal.
Automotor Journal	Automotor and Horseless Vehicle Journal.
Berlin, Akad. Sitzber	Sitzungsberichte der K. Preussischen Akademie der Wissenschaften, Berlin.
Berlin, K. Tech. Versuch. Mitth.	Mittheilungen aus den Koniglichen Technischen Versuchanstalten zu Berlin.
Bull. de la Belge Elect.	Bulletin de la Société Belge d'Electricien.
Cambridge Phil. Soc. Proc.	Cambridge Philosophical Society, Proceedings.
Cambridge Phil. Soc. Trans.	Cambridge Philosophical Society Transactions.
Canad. Elect. News	Canadian Electrical News.
Canad. Inst. Proc.	Proceedings of the Canadian Institute, Toronto.
Canad. Inst. Trans	Transactions of the Canadian Institute, Toronto.
Cassier	Cassier's Magazine.
Chem. News	Chemical News.
Comptes Rendus	Comptes Rendus de la Association Française pour l'Avancement des Sciences.
Deutsche Zeitschr. Elektrotechn.	Deutsche Zeitschrift für Elektrotechnik.
Dublin, Soc. Sci. Proc.	Scientific Proceedings of the Royal Dublin Society.
Dublin, Soc. Sci. Trans	Scientific Transactions of the Royal Dublin Society.

Abbreviations.	Full Title.
Écl. Électr.	L'Éclairage Electrique.
Elect. Engin. (London)	Electrical Engineer, London.
Elect. Engr. N. Y.	Electrical Engineer, New York.
Elect. Rev. (London)	Electrical Review (London.)
Elect. Rev. N. Y.	Electrical Review, New York.
Elect. World	Electrical World.
Electrician	The Electrician.
Électricien	L'Electricien.
Electricity, N. Y.	Electricity, New York.
Elekt. Runds.	Elektrotechnische Rundschau.
Elektrochem. Zeitschr.	Elektrochemische Zeitschrift.
*Elektrotechn. Zeitschr.	Elektrotechnische Zeitschrift.
*Elettricista (Rome)	Elettricista, Rome.
Elettricità, Milan	Elettricità, Milan.
Engineer	The Engineer.
Engineering	Engineering.
Eng. Mag.	Engineering Magazine.
Eng. News	Engineering News.
Frank. Instit. Journ.	Journal of the Franklin Institute.
Göttingen, Nachrichten	Nachrichten von der Königlicher Gesellschaft der Wissenschaften zu Göttingen.
Ind. Elect.	L'Industrie Électrique.
Ind. Electrochim.	L'Industrie Électrochimique.
Indus. & Iron	Industries and Iron.
Inst. Civ. Eng. Proc.	Proceedings of the Institution Civil Engineers.
Instit. Elect. Engin. Journ.	Journal of the Institute of Electrical Engineers.
Inst. Mech. Eng. Proc.	Proceedings of the Institution of Mechanical Engineers.
Journ. Chem. Soc.	Journal of the Chemical Society.
Journ. Electricity, S.F.	Journal of Electricity, San Francisco.
Journ. Phys. Chem.	Journal of Physical Chemistry.
Journ. Phys. Chim. Élem.	Journal de Physique, Chimie et Histoire Naturelle Elémentaires.
Journ. de Physique	Journal de Physique.
Journ. & Proc. of R. S., N. S. Wales	Journal and Proceedings of the Royal Society of New South Wales.
Journ. Télégraph	Journal Télégraphique.
Liège Ass. Ing. El. Bull.	Bulletin de l'Association des Ingénieurs-Électriciens, Liège.
Lightning	Lightning.
Manchester Lit. & Phil. Soc., Mem	Manchester Literary and Philosophical Society.
Math. Annalen	Mathematische Annalen.
Mech. Eng.	Mechanical Engineer.
*Mém. de l'Acad. roy. de Belgique	Mémoires de l'Académie royale de Belgique.
Moscow, Soc. Nat. Bull.	Bulletin de la Société Impériale des Naturalistes de Moscow.
N. Cimento	Nuovo Cimento (Pisa.)
*Nat.	Nature.
*Neues Jahrbuch für Mineralogie, Geologie, und Paleontologie	Neues Jahrbuch für Mineralogie, Geologie, und Paleontologie.
Paris, Soc. Franc. Phys., Bull.	Bulletin de la Société Française de Physique.
Paris, Soc. Franç. Phys., Séances	Séances de la Société Française de Physique.

Abbreviations.	Full Title.
Phil. Mag.	London, Edinburgh, and Dublin Philosophical Magazine.
Phys. Rev.	Physical Review.
Railroad Gazette	Railroad Gazette.
Railway World	Railway World.
Rev. de l'Él. Berne	Revue de L'Électricité, Berne.
Revue Scientif.	Revue Scientifique.
Rivista Scientifica	Rivista Scientifica.
Roma, R. Accad. Lincei, Atti	Atti della R. Accademia dei Lincei, Roma.
Roy. Soc. Proc.	Proceedings of the Royal Society of London.
*St. Petersburg, Accad. Sci. Bull.	Bulletin de l'Académie Impériale des Sciences de St. Petersburg.
St. Petersburg Accad. Sci. Mem.	Memoires de l'Académie Impériale des Sciences, St. Petersburg.
Schweizerische Blätter Elektrotechn. Berne	Schweizerische Blätter für Elektrotechnik, Berne.
Science	Science.
Scientific American	Scientific American.
Scientific Australian	Scientific Australian.
Soc. Arts Journ.	Society of Arts Journal.
Soc. Chem. Ind. Journ.	Journal of the Society of Chemical Industry.
Street Rly. Journ.	Street Railway Journal.
Street Rly. Rev.	Street Railway Review.
Torino, R. Acad. Sci. Mem.	Memorie della R. Academia delle Scienze di Torino.
Western Electn.	Western Electrician (Chicago).
Wien. Akad. Sitzber.	Sitzungsberichte der Mathmatisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenchaften.
Zeitschr. Analytische Chemie.	Zeitschrift für Analytische Chemie.
Zeitschr. Elektrochemie	Zeitschrift für Elektrochemie.
Zeitschr. Elektrotechn. Wien.	Zeitschrift für Elektrotechnik.
Zeitschr. Instrumentenk.	Zeitschrift für Instrumentenkunde.
Zeitschr. Instrumentenk., Beib.	Beiblatt zur Zeitschrift für Instrumentenkunde.
Zeitschr. Phys. Chem.	Zeitschrift für physikalische Chemie.

NOTE.—The *Séances de la Société Française de Physique* should be consulted for the full papers which are referred to in the *Bulletin de la Société Française de Physique.*

ERRATA.

Abstract No. 63, line 5 : *for* ·5271, *read* ·5971.

No. 237, line 1 : *for* Berlin, *read* Wien.

No. 264, line 12, *for* varies from point on S, *read* varies from point to point on S.

No. 272, p. 141, line 12 : *for* charged, *read* changed.

No. 290, line 1 : *for* Berlin, *read* Wien.

No. 305, line 13 from the end: *for* 1s. 10d., *read* $\frac{1}{10}$d.

No. 318, p. 163, line 6 : *for* showing the cost of cooking by coal to be about 19 per cent., *read* showing the cost of cooking by coal to be, on that basis, about 23 per cent.

No. 416, line 7 : *for* E.M.F. between upper and lower end of jet is measured, *read* E.M.F. between the two sides of the stream is measured along a line perpendicular to the lines of force and to the direction of flow.

No. 954, line 1 : *for* Electrician, 39, 1897, &c., *read* Electrician 40, pp. 218–219, 316–317, 511–514, 652–654, 814–817, and 41, pp. 108–110.

No. 1271, line 2 : *for* pp. 779–780, *read* pp. 547–548.

In Name Index : *for* Esehenburg, Behn, *read* Eschenburg.
for Garrigon, *read* Garrigou.
for Garbbasso, *read* Garbasso.
for Juman, *read* Jumau.
for Lagergreen, *read* Lagergren.
for Schevendener, *read* Schwendener.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JANUARY 1898.

GENERAL PHYSICS.

1. *The Process of Solidification.* **G. Tammann.** (Annal. Phys. Chem. 62. 2. pp. 280–299. 1897.)—The author seeks the most general form of the fusion-pressure curve, a precise definition of the solid state, and definite information concerning spontaneous crystallisation and rate of crystallisation. A knowledge of the latter is required for judging of the rate at which an undercooled liquid passes into the solid state. If a discontinuity of properties is made the basis of distinction between solid and liquid, the conclusion is arrived at that only crystallised bodies are in the solid state. For as far as experience goes, it is only during crystallisation that a discontinuous process sets in. Amorphous bodies must be regarded as undercooled liquids of great internal friction. The solid state is also distinguished by the fact that in it a certain group of properties depends upon direction. Amorphous bodies possess no heat of fusion. Hittorf found that the cooling-curve of liquid selenium, which hardens at 50°, is continuous. A retardation of the cooling by the evolution of heat of fusion does not take place at any point. There is a general notion that the spontaneous crystallisation capacity (*i. e.*, the number of crystalline nuclei formed during unit of time) increases continuously with falling temperature. But by counting these nuclei another result is obtained. The spontaneous crystallisation capacity possesses a pronounced maximum at a certain temperature, corresponding probably to a maximum attraction between the molecules. For betol, the salicyl ester of β-naphthol, with a fusing-point of 95°, there is a maximum at 10°. The rate of crystallisation may be defined as the distance by which the boundary between crystals and undercooled liquid is displaced in unit of time. If the under-cooling is less than the ratio between the heat of fusion and the specific heat of the solid substance, crystals separate out from the undercooled liquid at the boundary. These crystals are still

surrounded by liquid. The greater the undercooling, the less the quantity of liquid remaining among the crystals, until at last the liquid solidifies. If the rate of solidification is defined as that mass which is formed in unit of time at unit surface of the boundary, then the second rate of solidification will, at the temperature of total hardening, be equal to the first multiplied by the density. E. E. F.

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2. *Oxygen in the Sun.* **A. Schuster.** (Ast. Phys. Journ. 5. pp. 162–163, 1897.)—The author draws attention to the importance of the chromospheric lines at λ 5435·4 and λ 5329·1 being accurately measured by those who can work under sufficiently pure atmospheric conditions, as these lines are very near two of the oxygen triplets. If the chromospheric line could be proved triple, this would be a great step to the establishment of the presence of oxygen in the solar surroundings. C. P. B.

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3. *Oxygen in the Sun.* **L. E. Jewell.** (Ast. Phys. Journ. 5. pp. 99–100, 1897.)—Several papers have of late been published on this subject, with little or no definite conclusions. In the above article the author gives a concise account of his observations of the lines at wave-lengths 7772·20, 7774·43, and 7775·62 in the sun, which are amongst the suspected oxygen lines. With the great dispersion of the large concave grating at the Johns Hopkins Laboratory at Baltimore, he found the above lines to change their intensity with the varying altitude of the sun, thus definitely proving their *terrestrial* origin; and, further, their variation in intensity was quite different from that of the known atmospheric oxygen bands. This latter fact led to the lines being specially observed at times when the air had greatly different values of humidity, with the result that the above three lines, supposed to represent oxygen in the sun, are really produced by water-vapour in the earth's atmosphere. C. P. B.

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4. *Atmospheric Potential.* **R. Börnstein.** (Annal. Phys. Chem. 62. 4. pp. 680–686, 1897.)—The potential gradient above the earth's surface cannot be determined by mountain observations, since the equipotential surfaces follow the features of the landscape. Balloon observations are therefore necessary, and have been frequently resorted to. But in these the charge of the balloon itself is usually neglected. If the balloon is a conductor, it has the potential of the earth's surface to begin with. As it rises, its potential falls more and more below that of the surrounding space, since the earth's charge is negative. If it is an insulator, its charge is little affected by loss of gas or ballast. It may be due to the effect of the sunlight or to friction between the netting and the envelope. The potential observations might

be corrected for the balloon charge by taking horizontal observations at some distance from the balloon. But the technical difficulties of carrying suitable poles, etc. are very great. It is better to determine the charge of the balloon by three successive points in a vertical line. If these are, say, $2m$ apart, the earth's charge will be negligible. If the two vertical distances show equal gradients, the balloon's charge is zero. If not, its charge may be determined by the formula

$$-\frac{\partial^2 V}{\partial r^2} = \frac{2M}{r^3},$$

where V is the potential, r the distance below the car, and M the charge of the balloon. E. E. F.

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5. *Elliptic Vibrations in Fluids.* **V. Crémieu.** (Comptes Rendus, 125. pp. 935–937, 1897.)—Only longitudinal vibrations can be propagated through fluids, and in these the direction of propagation coincides with that of the motion of the vibrating molecule. The author has made experiments to find whether, in spite of this peculiarity, elliptical vibrations can be demonstrated in a gas corresponding to those which are well known to be produced by the composition of two rectangular transveral vibrations having the same period and a given difference of phase. He uses two identical organ-pipes of square section, closed at one end, and crossing at right angles at a point P, which is for each of them an antinode; the walls of the pipes at this common part P are of glass. The movements of the air in this region P are examined by means of a quartz-fibre (of about 0·05 mm. diameter) attached at one end to soft wax, and placed perpendicularly to the direction of the vibrations: the free end follows exactly all the movements of the gas. The vibrations are produced by two tuning-forks of equal period, maintained electrically, and provided with square plates of the same size as the section of the pipes. Instead of arranging to maintain a constant difference of phase between the forks, it is found more convenient to regulate them so that they give, by interference, beats having a period of ten seconds. Under these circumstances the resulting vibratory motion should vary from a right line to a circle, with all the intermediate forms of ellipse. Observation of the free end of the quartz-thread shows that this is the case. D. E. J.

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6. *Closed Surfaces of Discontinuous Velocity.* **W. Wien.** (Annal. Phys. Chem. 62. 1. pp. 192–203, 1897.)—In a liquid surrounded by solid walls and not subjected to rotation, no motions can occur unless discontinuities of velocity are produced. But within the liquid closed surfaces may be formed at which the velocities are discontinuous, thus producing, as it were, a complex space, within which circuital flows may take place. Such motions

may, and do, occur in the atmosphere. The author works out the mathematical conditions of some simple types of these motions in an incompressible frictionless liquid. E. E. F

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7. *Variation of Spectrum of Orion Nebula.* (Ast. Phys. Journ. 6. pp. 363–366, 1897.)—Prof. Campbell's observations of the variable intensity of the three nebula lines at wave-lengths 4861, 4959, and 5007 having been questioned by Dr. Scheiner, additional confirmation of their change in various regions of the nebula is given by three independent observers—J. M. Schaeberle, R. G. Aitken, and W. H. Wright. All agree that in the vicinity of the Trapezium the three lines are all well marked, λ 5007 being several times as bright as λ 4861 ($H\beta$), while away in the neighbourhood of the star Bond 734 the hydrogen line λ 4861 is the only line visible. In another region λ 5007 was again visible, together with $H\beta$, but the latter was still much the brighter of the two. These observations leave little doubt as to the actual variation of the nebular spectrum. C. P. B.

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8. *Meteor Spectrum.* **E. C. Pickering.** (Nat. 57. p. 101, 1897.)—So far as is at present known, this is the first observation of any certain value bearing on the spectra of meteorites as they actually fall through the atmosphere. On June 18, 1897, a plate exposed at 11 P.M. at Arequipa, in Peru, on the region surrounding the southern constellation, Telescopium showed on development the spectrum of a meteor which had fallen during the exposure. The instrument was the 8-inch Bache telescope, with prisms outside the objective, with which most of the Draper memorial star-spectra have been obtained. The spectrum shows six bright lines, of varying intensity, whose position can only be provisionally measured owing to the absence of a comparison-spectrum with known wave-lengths. The approximate wave-lengths given are :—

$\lambda\lambda$ 3954, 4121, 4195, 4344, 4636, and 4857.

Of these, λ 4121 seems suspiciously near a line seen in one of the components of helium gas, while λ 4857 is very probably identical with the hydrogen line λ 4861 ($H\beta$). C. P. B.

LIGHT.

9. *Röntgen Rays.* **A. Voller** and **B. Walter.** (Annal. Phys. Chem. 61. 4. p. 806, 1897.)—The authors regret having overlooked Winkelmann and Straubel's recent work on the refraction of X-rays in copper and iron, the results of which agree more closely with their own. E. E. F.

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10. *Action of Röntgen Rays on the Skin.* **L. Lecercle.** (Comptes Rendus, 125. p. 583, 1897.)—When Röntgen rays fall upon the skin, the radiation of heat from the skin is increased, and remains greater for a long time after the rays have ceased to act. In many cases the first result is a slight fall in the radiation. A. D.

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11. *Röntgen Rays and Luminescence of Gases.* **A. de Hemptinne.** (Comptes Rendus, 125. pp. 428–429, 1897.)—A tube containing a gas at a very low pressure becomes luminous if exposed to electric vibrations. The same effect takes place at higher pressures if Röntgen rays be passing through it. This result is more marked in organic vapours than in simple gases, and among the former it is the more marked the higher the molecular weight. A. D.

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12. *Absorption of Röntgen Rays.* **A. Buguet.** (Comptes Rendus, 125. pp. 398–400, 1897.)—By means of a sensitometer containing squares of various thicknesses, the author finds that the relative opacity to Röntgen rays, per unit of thickness, diminishes as the thickness increases, and diminishes very rapidly for the layers successively encountered. As the Röntgen rays come from tubes of increasing resistance, the first layers of tin are found to absorb the rays more powerfully, but the succeeding layers less so. An instrument is described (fluorescent screen behind a series of obstacles of graduated substance and thickness) for ascertaining the intensity of the radiation, and also the specific absorption of the radiation from any given tube. A. D.

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13. *Magnetic Deviation of Kathode and Röntgen Rays.* **G. de Metz.** (Comptes Rendus, 125. pp. 426–428, 1897.)—The deviation (see Phys. Soc. Abstracts, No. 570, Oct. 1897) takes place when a layer of air intervenes, but not quite so well as when the exhausted tube containing the aluminium cylinder is directly melted on to the Crookes tube. A. D.

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14. *Absorption of Röntgen Rays.* **E. van Aubel.** (Journ. de Physique, 6. pp. 528–529, 1897.)—Bromine vapour at ordinary temperatures is very transparent, liquid bromine very opaque, to Röntgen rays. A. D.

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15. *Existence of Röntgen Rays in Kathode Rays.* **A. Ròiti.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 123–129, 1897.)—Some answer this in the affirmative; most say no. The Röntgen rays are broadly distinguished from the kathode rays by their not being deviated by a magnet and by their greater penetrative power; but this is a matter of degree: and so also is the turbidity of media for the kathode rays as compared with their transparency for the Röntgen rays. Röntgen himself seems to regard the idea of a shading off of the one into the other without disfavour. But there is some distance between this and the assertion that the Röntgen radiations are obtained from the kathode radiations by simple subtraction; and this latter does not appear to be the case, for the following reasons:—(1) The phenomena of discharge and ionisation are inexplicable on this hypothesis. (2) Every point of a body under kathode rays gives off Röntgen rays *in all directions.* (3) Deviate the kathode rays in the tube, and photographic and screen images are displaced and modified: this would not occur if they were due to Röntgen rays, not deviable, and pre-existent among the kathode rays. (4) If there be any undeviable rays among the kathode rays these, in their intensity, fall far short of the Röntgen rays from the same tube. (5) The analogy of calorescence or of fluorescence is sufficient as providing an explanation. (6) Kathode rays which have traversed a thin layer emerge into air or a vacuum as kathode rays, not as Röntgen rays. (7) Reflection of kathode rays is irregular because surfaces are never sufficiently smooth, even optically smooth surfaces being rough in relation to these rays. (8) Röntgen rays come from an appreciable depth beneath the surface; they, therefore, do not follow the cosine law, but are the same in all directions. As we increase the thickness of the aluminium window we pass from Lenard's condition, transmission of kathode rays, to Röntgen's, viz. production of Röntgen rays. Photography within a tube, under black paper, etc., not too thin, is, therefore, a Röntgen-ray effect. (9) Lenard missed the Röntgen rays through having his aluminium windows too thin: it then seemed as if the whole of the radiation was deviated by the magnet. Also, his screen was fluorescent to kathode, but not to Röntgen, rays. (10) In a focus-tube the radiations from the anti-kathode contain other radiations than Röntgen rays, also said to differ from the kathode rays in respect that they cannot excite Röntgen radiation and are not produced from the incident beam either by regular or by diffuse reflection. They do, however, excite a feeble Röntgen radiation, and the want of regular reflection is explained above.—Experiments are described to confirm the result that the Röntgen radiation is due to transformation and not to simple subtraction. It is shown that probably there exist no undeviable

kathode rays, or, if they exist, they are not transformable into Röntgen rays. Eliminating the effects of occluded or adherent gas, it is found that different metals, in the pure state, have powers of emitting Röntgen rays under kathode-ray impact which increase regularly, not with the density or with the atomic volume, but with the atomic weight. A. D.

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16. *Infra-red Rays.* **J. Königsberger.** (Annal. Phys. Chem. 61. 4. pp. 687–704, 1897.)—The author describes some extensions of Merritt's work on the absorption and pleochroism of crystals for infra-red rays. The substances examined were baryta, celestine, gypsum, calcspar, aragonite, cerussite, quartz, amethyst, mica, biotite, and beryllium. In comparing the transparency-curves of calcspar and aragonite, it was found that for vibrations along the axis which in twinned aragonites corresponds to the hexagonal axis of the calcspar, the curve is similar to that for the extraordinary ray in calcspar. This may be connected with the fact, mentioned by Ångström, that the state of aggregation of a substance has often little influence upon its transparency. Bunsen also noticed that crystallised and dissolved didymium sulphate had practically the same sharp absorption-bands, and in the case of gypsum it appears that water of crystallisation has only little influence. Pleochroism at any part of the spectrum is usually due to a slight displacement of one transparency curve with respect to that for another crystalline axis. Such pleochroism for the invisible rays is especially strong in calcspar and aragonite.

E. E. F.

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17. *Le Bon's "Dark Light."* **H. Becquerel.** (Journ. de Physique, 6. pp. 525–528, 1897.)—Le Bon's results are not due to the transparency of ebonite to white light (Perrigot), so much as to its great transparency to the least refrangible red and the infra-red. These rays extinguish the phosphorescence of a luminescent screen, which remains less affected where a metal object, such as a coin, has sheltered the screen from these rays. Further, if a photographic plate be slightly fogged by white light, these rays—particularly those in the neighbourhood of line A—continue the action on the film, as Becquerel *père* found with daguerreotype plates in 1840. Behind a coin, therefore, the fog remains as at first, while round it the deposit of silver is dense. The exposure must be prolonged, but if it be too prolonged the phenomena of "reversal" may appear and the region outside the coin may clear up, leaving the original condition of fog beneath the coin. Precisely similar results may be obtained with red glass instead of ebonite. Ebonite 0·6 mm. thick transmits 0·04 of the dark heat from a copper plate at 400°, but hardly any of that from the same plate at 100°. A. D.

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18. *Photography of Fluorescent Image.* **Ch. Porcher.** (Comptes Rendus, 125. pp. 409–410, 1897.)—There is nothing gained, either in time or in definition, by photographing the shadow image produced on the fluorescent screen by Röntgen rays.
A. D.

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19. *Grey and Red Incandescence.* **O. Lummer.** (Annal. Phys. Chem. 62. 1. pp. 14–29, 1897.)—H. F. Weber observed in 1887 that the first appearance of light in a glowing substance is not red, but a misty grey, which flits about and cannot be accurately located with the eye. This is explained by the author on the assumption that the grey glow is a sensation of the rods in the retina, and the red glow a sensation of the cones. When the grey glow sets in (about 400°) the fovea centralis is unaffected, since it contains cones only. It is, therefore, impossible to fix the eye upon the glowing body, which is only seen by the peripheral regions of the retina. As soon as the red glow begins the centre of vision is brought into play, and the image becomes steady.
E. E. F.

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20. *Observation and Theory of Zeeman Effect.* **A. Cornu.** (Comptes Rendus, 125. pp. 555–561, 1897.)—Zeeman's arrangements (Phil. Mag., July & Sept. 1897) are modified as follows. In the focal plane of the eye-piece with which the spectrum is observed is placed a steel needle perpendicular to the spectral lines. Behind the eye-piece is placed a Wollaston doubly-refracting prism, and this is adjusted so that the two images of the needle which it produces have a common edge. We thus have two adjacent strips, one (A) polarised parallel to the spectral lines, the other (B) at right angles to them. Before exciting the electromagnet, the prism is arranged so that the polarised spectra exhibit no discontinuity at their common edge. The effect of exciting the magnet when we observe a bright spectral line derived from a pencil of rays perpendicular to the lines of force, is that the part of the line which is in B becomes doubled; the part in A becomes narrower and lies halfway between the two bright lines in B. The conclusion is that each original non-polarised ray is transformed into a triplet the exterior components of which are completely polarised parallel to the lines of force, while the interior component is completely polarised at right angles to them.

A second observation is made (through a hole in one armature) on a pencil parallel to the line of force. Between the eye-piece and the prism is introduced a quarter-wave plate of mica so that its principal planes are inclined at 45° to those of the prism. When the magnet is excited the two parts of the bright line become narrower, and there is a break at the line of separation of the spectra. When the mica-plate is turned through a right angle the relative position of the two parts is reversed; the same reversal is also produced by reversing the magnetic field. It is inferred that the magnetic field transforms each primitive ray into two, both circularly polarised, but in opposite senses.

After describing another method of observation by means of a Nicol's prism and plates of mica, the author gives a kinematical interpretation, based upon Fresnel's resolution of a plane-polarised ray into two equal and opposite circularly polarised rays, and Ampère's proposition that a line of magnetic force is equivalent to the axis of a solenoid whose austral pole is to the left of the current. The inference drawn is that "the action of the magnetic field tends to resolve those rectilineal vibrations which are capable of wave-propagation into circular vibrations parallel to the current of the solenoid; those circular vibrations which are in the same sense as the current being accelerated, and those which are in the opposite sense being retarded." Attention is called to the fact that the alterations of period involved essentially distinguish the phenomenon from Faraday's rotatory effect. G. B. M.

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21. *Magneto-Optic Effects.* **P. Drude.** (Annal. Phys. Chem. 62. 4. pp. 687–692, 1897.)—The author points out that his theory of magneto-optic effects, as amplified in 1894, is as well capable of accounting for all the observed phenomena as that of Leathem. The real magneto-optic constant of his theory is complex, and there are in reality two such constants. The fundamental equations of Leathem's theory may be at once reduced to those of the author's. One of Leathem's further equations (No. 10) may be interpreted as representing a Hall effect for conduction and displacement currents, but no connection between the Hall effect and magneto-optic phenomena has as yet been actually established.
E. E. F.

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22. *Optical Phenomena in a Magnetic Field.* **A. A. Michelson.** (Ast. Phys. Journ. 6. pp. 48–54, 1897.)—With a view of testing the work of the late M. Fievez, who found that the spectral lines of a source subjected to a magnetic field were reversed and doubly reversed instead of being simply widened, the author has examined the spectra of several substances with his interferential refractometer, using the now well-known "visibility" method. Curves are given showing both distinct doubling and widening of the lines, although much evidently depends on the direction and intensity of the magnetic field. It appears that up to a strength of field of 2000 C.G.S. the chief effect is simply a doubling of the lines; beyond this strength the component lines are broadened as well as separated. The degree of separation is nearly proportional to the strength of field. The broadening effect is much more marked when the light under examination issues at right angles to the magnetic field than when it lies along the lines of force. This the author thinks may be accounted for by the radiating atoms having a new velocity impressed upon them at right angles to the original one, the resultant velocity giving the broadening effect. C. P. B.

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23. *Interferential Spectroscopy.* **A. Perot** and **C. Fabry.** (Comptes Rendus, 126. pp. 34–36, 1898.)—In a former paper (C. R. 123. p. 802) the authors have shown the ease with which fringes can be obtained by means of two glass plates enclosing a thin film of air, the internal surfaces of the glasses being thinly silvered. They give here a description of the application of this arrangement to delicate spectrometry, stating that for some purposes the method is more suitable than that of Michelson. C. P. B.

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24. *Related Spectra.* **C. Runge** and **F. Paschen.** (Annal. Phys. Chem. 61. 4. pp. 641–686, 1897.)—The three spectra of oxygen, sulphur, and selenium show a regular structure. They all have "compound" spectra whose lines occur in series obeying the laws indicated by Rydberg and by Kayser and Runge. There is also a connection between the three spectra. As the atomic weight increases, the spectrum as a whole moves towards the greater wavelengths. The sulphur and selenium compound spectra show some lines which have not hitherto been observed, and may help to explain some strange lines in the spectra of heavenly bodies. Besides the six triplets observed by Piazzi Smyth, the authors have found seven more in the oxygen compound spectrum, which, together with the former, make up two series. They correspond to the two series of triplets observed by Kayser and Runge in the spectra of Mg, Ca, Sr, Zn, Cd, and Hg. Two such series are also found in cleveite gas, and the argument as to the compound character of this gas from its spectrum is therefore without foundation. E. E. F.

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25. *Spectral Photometry.* **D. W. Murphy.** (Ast. Phys. Journ. 6. pp. 1–21, 1897.)—After describing the double-slit collimator of Vierordt's photometer, the author describes a series of experiments undertaken to test the accuracy of Vierordt's statement that the intensity of a spectrum is proportional to the slit-width. He comes to the conclusion that it is not strictly true, the error varying from 1 or 2 per cent. in the blue to as much as 10 per cent. in the red.

In the same paper there is a useful description of an experimental determination of the truth of Fresnel's formula for the intensity of light reflected from certain media. C. P. B.

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26. *Emission Spectra.* **A. C. Jones.** (Annal. Phys. Chem. 62. 1. pp. 30–53, 1897.)—Zinc and cadmium salts were placed in a discharge-tube having a narrower and a wider portion, so as to examine the influence of the intensity of the discharge upon the spectrum yielded under the discharge of an influence-machine. Mercuric haloid salts were examined in the same way. The results, which are very complex, are embodied in tables and curves. E. E. F.

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27. *Formula for Wave-lengths of Spectra.* **J. J. Balmer.** (Ast. Phys. Journ. 5. pp. 199–209, 1897.)—There has long been known to be some connection between the various spectral lines of many of the elements as regards their vibration-frequency, which has hitherto only found definite expression in the case of hydrogen by the well-known Balmer's Law. Of late Runge and Paschen, of Hanover, have been specially investigating the spectra of the elements with very great dispersion, and have been successful in mapping out definite series in many bodies. They find that in general each element is represented in its spectrum by three series, one principal and two subordinate. Furnished with the accurate determinations of wave-lengths for certain metals, Balmer has been able to furnish a more universal formula, given on p. 202. C. P. B.

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28. *Effect of Pressure on Wave-length.* **W. J. Humphreys.** (Ast. Phys. Journ. 6. pp. 169–232, 1897.)—The author brings together all the available data on the questions which have been previously published, and in addition gives a considerable amount of new matter. Detailed tables are given showing the change in wave-length produced by graduated increments of pressure on the arc spectra of forty-nine elements, from which certain definite functional relationships have been deduced. A short summary of the results is as follows:—

1. *Increase of Pressure* causes all isolated lines to shift towards the *red* end of the spectrum.
2. This displacement is *directly* proportional to the increase of pressure.
3. It does not depend on the partial pressure of the gas or vapour producing the lines, but upon the total pressure.
4. The displacement of the lines seems to be nearly or quite independent of the temperature.
5. The lines of bands (at least of certain "cyanogen" and aluminium-oxide bands) are not appreciably shifted.
6. The displacements of similar lines of a given element are proportional to the wave-lengths of the lines themselves.
7. Different series of lines of a given element are displaced to different extents. When reduced to the same wave-length these displacements are to each other approximately as 1 : 2 : 4 for the principal, first, and second subordinate series respectively.
8. Similar lines of an element, though not belonging to a recognised series, are displaced equally (when reduced to the same wave-length), but to a different extent than are those unlike them.
9. Displacements of similar lines of different substances are to each other, in most cases, *inversely* as the absolute temperatures of the melting-points of the elements that produce them.

10. The displacements of different lines of different elements are to each other approximately as the products of the coefficients of linear expansion and the cube roots of the atomic volumes of the respective elements (in the solid state) to which they are due.
11. Analogous or similar lines of elements belonging to the same half of a Mendelejeff group shift proportionately to the cube roots of their respective atomic weights.
12. The lines of those substances which, in the solid form, have the greatest coefficients of linear expansion show the greatest displacements. The converse is also true.
13. The displacements of similar lines is a periodic functiou of atomic weight, and consequently may be compared with any other property of the elements which itself is a periodic function of their atomic weights. C. P. B.

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29. *Wave-length of Starlight.* **G. C. Comstock.** (Ast. Phys. Journ. 5. pp. 26–35, 1897.)—By the use of Michelson's method of producing interference-fringes at the focus of a telescope by placing over the object-glass a screen with two rectangular slits cut in it with their axes parallel to each other, the author has obtained values for the integrated intensity of the light from fifty-five stars, varying in magnitude from 0·5 to 6·5. An approximate agreement is shown between the effective wave-length and the colour of the star; so much so, that a general classification is given, from which it seems that the *white* stars have an effective wave-length about λ 5640, the *yellow or solar* stars about λ 5730, and the *red* stars with banded spectra about λ 5750. The author concludes that the light from stars which are distinctly coloured has a maximum intensity 9 $\mu\mu$ greater than that from white stars, while it is not sensibly different from that from those of the deepest red colour. C. P. B.

HEAT.

30. *Two-Liquid Phases.* **W. D. Bancroft.** (Journ. Phys. Chem. 1. pp. 647–668, 1897.)—This is a continuation of a former paper (see Phys. Soc. Abstracts, No. 395, July 1897). A graphical summary is given of the states of equilibrium in three-component systems when one pair, two pairs, and three pairs of the components can form two-liquid phases. Thirteen cases here occur, and the two results are too intricate to be indicated in an abstract. The variations that occur with change of temperature are not discussed. The dependence of the conditions of equilibrium upon the relative miscibilities of the components and the dissociations that may occur is discussed. The latter have special importance in the case of equilibrium between gases and solids where no liquid phase is present and also in certain cases of equilibrium in solutions; the former affect all solutions, but their effect is often negligible at certain temperatures. R. E. B.

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31. *Hygrometry.* **G. B. Rizzo.** (N. Cimento, 4. 6. pp. 241–260, 1897.)—After an historical account, with numerous references, of the progress of hygrometry from Cullen and Hutton onwards, the author describes a series of experiments in which he compared the readings of Crova's hygrometer with Chistoni's form of Regnault's instrument; he concludes that when proper precautions are taken Crova's hygrometer is very trustworthy and preferable to other condensing hygrometers. An account is then given of a comparison of the readings of Crova's hygrometer with those of the dry- and wet-bulb hygrometer: the conclusion is that, if the instrument is placed in a cage of the form generally used by Italian meteorologists, the tension of the aqueous vapour in the atmosphere may be calculated by the formula

$$f = F' - 0{\cdot}000749\,H(t-t') + 0{\cdot}0000000079\,H^2(t-t')^2,$$

where t is the temperature of the air, t' the reading of the wet-bulb thermometer, H the barometric pressure, and F' the maximum vapour-tension corresponding to the temperature t'. G. B. M.

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32. *Irreversible Phenomena.* **O. Wiedeburg.** (Annal. Phys. Chem. 61. 4. pp. 705–737, 1897.)—The author seeks a general formulation for the actual processes in time which always take place in a certain "direction," and are therefore called irreversible. He treats heat in the same manner as other forms of energy. To represent the mutual influence of two bodies, he uses the categories of quantities, intensities, resistances, and energies, with the aid of which the transition law may be put into various forms. Applying the theorem of the constancy of the sum of quantities to thermal phenomena, a precise and complete expression is obtained for the

second law of thermodynamics, and it is recognised that the theorem of maximum entropy is based upon a fallacy due to imperfect formulation. The foundations of the author's studies are the "equations of condition," which express the various aspects of the condition of a body at any given time. In these equations, quantities and intensities are opposed to each other, and irreversible processes are indicated by terms of the second order. In this manner heat is effectually brought into line with other forms of energy, and is made to include some phenomena (*e. g.* after-effect) which had previously to be treated separately. E. E. F.

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33. *Compressibility of Gases.* **A. Leduc.** (Comptes Rendus, 125. pp. 646–649, 1897.)—This paper is a continuation of a former one (see Phys. Soc. Abstracts, No. 603, Oct. 1897; C. R. 125. pp. 297–299, 1897). The present communication contains a much fuller table than the last, giving values of certain constants for a large number of gases, the constants not having a direct physical meaning in themselves, but being connected with the equations for the compressibility given in the former paper. The author has found a connection between these constants and some of the physical properties of the gases. J. B. H.

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34. *Expansion of Gases.* **A. Leduc.** (Comptes Rendus, 125. pp. 768–770, 1897.)—From the results of a former experiment by the author on the density of one of the gases at 0° and 760 mm. and his experiments on the compressibilities of a number of gases at 16°, he has calculated their coefficients of expansion. The results are given in tabular form, and agree remarkably with those obtained by experiment.

It is impossible to give here any idea of the methods of calculation, as this paper, together with the other by the same author abstracted above, and a third referred to, form in reality one investigation, the equations of the first paper being used in the others. J. B. H.

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35. *Meaning of* PV/T *in Theory of Gases.* **C. Del Lungo.** (N. Cimento, 4. 6. pp. 273–277, 1897.)—This is a continuation of a polemic with Professor Boggio-Lera. The value of R ($=PV/T$) for hydrogen is nearly the same numerically as the mechanical equivalent of heat; the author proves that this circumstance is quite accidental. G. B. M.

SOUND.

36. *Organ-pipe with Movable End.* **Neyreneuf.** (Annal. Chim. Phys. 12. pp. 140–144, 1897.)—The author investigates the variation in pitch and quality of the note given out by an organ-pipe which is rapidly shortened or lengthened by the movement of the end of the pipe towards or away from the mouth.

J. W. C.

37. *High Pitch.* **C. Stumpf** and **M. Meyer.** (Annal. Phys. Chem. 61. 4. pp. 760–779, 1897.)—The authors tested the usual sources of very high notes, viz. Galton's whistle, Appunn's whistles, Appunn's small tuning-forks, and König's forks. They found very serious discrepancies between the indicated and the actual values. The tests were carried out by the method of difference tones. The highest note audible on Galton's whistle was 14,000. It was found important to have a constant air-pressure, as the pitch might vary 10 per cent. on varying the blast. Appunn's pitch pipe no. 62, supposed to give a note of frequency 50,880, was actually found to give one of 10,900. The cause of all these discrepancies lies in the fact that there is no continuous rise of pitch in the series, and this defect can only be discovered by very careful attention to the gaps. E. E. F.

38. *Acoustic Resonators.* **P. Lebedew.** (Annal. Phys. Chem. 62. 1. pp. 158–173, 1897.)—The author investigates the ponderomotor forces due to the mutual influence between the exciting wave and the forced vibrations of the resonator, as distinguished from the direct action of the wave and the reaction of the resonator. He uses a Kundt rod as a source of sound, and a short thin-walled glass tube, tuned by a cork stopper, as resonator. He finds that a plane wave falling on the resonator repels it from the source. This repelling force is a maximum for perfect unison. In the immediate neighbourhood of the source, the analogy between the behaviour of acoustic and electromagnetic resonators is perfect.

E. E. F.

ELECTRICITY.

39. *Electric Conductivity of Discontinuous Conductors (Coherers).* **E. Branly.** (Comptes Rendus, 125. pp. 939–942, 1897.)—Marconi's experiments have again drawn attention to the electrical behaviour of tubes of metallic filings, and generally to the conductivity of discontinuous conductors. The author has made further experiments on the best conditions for sensitiveness, and the results confirm those first announced by him in 1891 (*cf.* La Lumière Electrique, May & June, 1891). He objects to the name 'coherers' given by Lodge to his tubes. D. E. J.

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40. *Dielectric Strength of Oils.* **E. F. Northrup** and **G. W. Pierce.** (Elect. World, 30. pp. 559–560, 1897.)—The oils under test are subjected to pressures from a high-frequency coil, a transformer, and an induction-coil. The high-frequency coil was capable of giving a smooth continuous discharge through 10 inches of air; the induction-coil gave a heavy 4-inch spark, and the same coil used as a transformer with 100 volts on the primary discharged through about half an inch of air. In the following table, which is a brief summary of the results, the numbers give the maximum and minimum ratios of oil-strength to air-strength through the range tested.

Kind of Oil.	High Frequency Coil.	Transformer.	Induction-Coil.
Transit	14—24·8	7·8—·9	3·9—9·7
Engine	29·1—37·2	5·8—·99	3·9—16
Kerosene....	47·6—67·5	21—26·6	10·3—35

These results show that kerosene is the best insulator. W. G. R.

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41. *Dielectric Strength of Oils.* **C. P. Steinmetz.** (Elect. World, 30. pp. 609–610, 1897.)—The author quotes some results given in a paper by Messrs Northrup and Pierce in the 'Electrical World' of November 6th, viz.:—

First.—The ratio of oil-strength to air-strength depends upon the source of power, being lowest under the strength of alternating currents, highest with oscillating currents of a high frequency, and intermediate with the current of an induction-coil.

Second.—The ratio of oil-strength to air-strength increases with the striking distance, that is, the voltage, except with heavy oils and alternating currents.

Third.—In the latter case the strength of oil falls to, or even below, that of air at high voltages.

He does not think that the shape of the wave is the cause of these differences, but rather the powerfulness of the source of

supply. He also remarks that in his opinion dry oils have a dielectric strength far superior to that of air at high voltages with alternating currents. W. G. R.

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42. *Electric Discharge.* **H. Ebert** and **E. Wiedemann.** (Annal. Phys. Chem. 62. 1. pp. 187–191, 1897.)—A cylindrical cage with fine meshes is made partly to fill up a vacuum-tube. The end walls act as supernumerary anode and kathode respectively, the light being most intense at the end of the cage farthest away from the end of the tube. When the cage fills up nearly the whole of the tube, the discharge has considerable difficulty in passing at all. Rarefied gases are often better conductors than metals. E. E. F.

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43. *Insulating Materials.* **F. W. Phisterer.** (Elect. World, 30. pp. 554–556, pp. 583–585, and pp. 610–611, 1897.)—The requirements of a good insulating substance are that it should be waterproof, fireproof, tough, flexible; it should possess the power of closing again any cracks which may occur in it from any cause, and it should be easy of application and cheap to manufacture, as well as being a good insulator.

The author considers many insulating substances, such as sulphur, silex, various asphalts, pitches, mineral wax, sapho, ozite, and paraffin wax, and gives a very complete account of what is known of their various physical qualities. Mixtures of these substances are also dealt with, and an amount of information on the subject is given which is not obtainable elsewhere in a collected form. W. G. R.

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44. *Action of Radiation on Sparks.* **A. Sella.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 184–191, 1897.)—The author describes a quantitative method of studying the action of the radiation from one spark on another. Across the terminals of the gap of the latter spark is connected a coil of wire which is placed in a vessel, of 5 litres volume, containing air. When a discharge passes part of the current goes through the coil, and the heat produced causes the air to expand, and thus drives a column of mercury along a tube connected with the vessel. There are some pretty and ingenious devices described, for making the vessel act at various temperatures and pressures. The effect of the radiations is to considerably diminish the quantity of heat produced in the shunt-coil. A. Gs.

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45. *Ballistic Galvanometers.* **M. Wien.** (Annal. Phys. Chem. 62. 4. pp. 702–705, 1897.)—Describes a method of standardising a ballistic galvanometer by means of a coil of known self-induction. It is a reversal of Maxwell's method for measuring self-inductions by the Wheatstone bridge and a ballistic galvanometer. Since

self-inductions can be more correctly determined by alternating currents, this reversal has a distinct advantage. The theory of the method results at once from Maxwell's equations. The constant of the galvanometer is

$$b = \frac{Jp}{4a(r_0 + r)},$$

where J is the constant current, p the self-induction, a the deflection, r_0 the resistance of the galvanometer circuit, and r that of each bridge branch. To avoid heating, the deflection should only be measured at break of the current. E. E. F.

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46. *Hall Effect in Liquids.* **F. Florio.** (N. Cimento, 4. 6. pp. 108–113, 1897.)—The author continues his discussion with Bagard as to whether the Hall effect exists in liquids, and still holds a negative opinion. A. Gs.

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47. *Absorption of Waves in Electrolytes.* **A. Eichenwald.** (Annal. Phys. Chem. 62. 4. pp. 571–587, 1897.)—Maxwell's fundamental equation

$$\frac{\partial^2 X}{\partial t^2} + \frac{4x\sigma}{\epsilon} \cdot \frac{\partial X}{\partial t} = \frac{V^2}{\mu\epsilon} \frac{\partial^2 X}{\partial z^2}$$

can only be fully tested by investigations bearing on the propagation of electric force in conductors, since it is only in these that all the terms come into action. The electric conductivity of electrolytes has an important bearing on this matter. The author used a modification of Zeeman's method, in which the absorption is followed along wires laid through the electrolyte by means of a bolometer, and obtained results which are in close agreement with Maxwell's equation. E. E. F.

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48. *Luminous Excitation of a Gas.* **H. Ebert** and **E. Wiedemann.** (Annal. Phys. Chem. 62. 1. pp. 182–186, 1897.)—The authors deal with the conditions under which a low-pressure gas is excited to luminosity in a high-frequency alternating field. The ordinary appearance of the tube with flat ends shows the kathode phenomenon (dark space and glow) next the plates, and the positive light in the middle, separated on each side by a dark space. If exhaustion is carried very far, the two kathode-spaces gradually displace the positive light and finally they coalesce. As soon as this happens the luminosity ceases altogether. This phenomenon is not a mere question of pressure. For, if four bulbs of various dimensions are simultaneously exhausted by the same pump and placed in position, the extinction takes place first in the smaller bulbs. If the diameter is reduced tenfold, the pressure at which extinction takes place is increased 22 times. But the length, and not the width, is the determining factor. It is immaterial whether the ends of the cylinder are of glass or

metal, and the nature of the gas is without influence. If the kathode formation is deflected aside by a magnet, the tube lights up again. E. E. F.

49. *The Resistivity of Reostene.* **E. Van Aubel.** (Journ. de Physique, 6. pp. 529–531, 1897.)—This alloy, a nickel-steel, due to W. T. Glover, Salford, brazes easily and can be soldered with ordinary solder. Its density is 7·8991. The resistivity at 0°·44 is 77·07 microhm-centimetres, with a coefficient of variation of 0·00119 between 0°·44 and 14°·47, of 0·00116 between 15°·6 and 57°, of 0·00114 at 74°·1 and of 0·00098 between 74°·1 and 100°·5. The resistivity is thus very high and the coefficient of variation is fairly constant between 0° and 74° C., a property which other alloys do not possess. When this alloy is cooled to 0° C. after being heated, it regains its original resistivity completely. A. D.

50. *Permanence of Resistance-Coils.* **W. E. Ayrton.** (Electn. 40. pp. 39–40, 1897.)—In 1894 the resistances of two coils of manganin and two coils of platinum-silver were tested by Glazebrook at Cambridge. In 1896, and again in 1897, the same four coils were tested by Cardew at the Board of Trade laboratory. The results agree fairly well as regards the *resistance* of the coils, comparing the 1894 with the 1897 tests, but there is disagreement between the 1894 results and those of 1896—in one coil of 10 ohms (platinum-silver) there is a difference of the order of 0·001 ohm. Again, comparing the *temperature coefficients*, the original 1894 values are in all cases lower than those calculated from the 1894, 1897, resistance tests; this is especially the case with the two manganin coils. The rate of change of the temperature coefficient of the two platinoid coils respectively appears here to be the same; similarly for the two manganin coils. But this latter result does not obtain true for calculations based on the 1896, 1897, tests. The author concludes that when tested in 1896 the coils were under abnormal conditions. R. A.

51. *Our Knowledge of the Value of a Resistance.* **W. E. Ayrton.** (Electn. 40. pp. 149–150, 1897.)—After stating the limits of accuracy of a determination of an ohm given by the Board of Trade, viz., one-hundredth of 1 per cent., the author enquires whether this same percentage accuracy is attainable for a resistance of any value, whether this value be 100,000 ohms, 10,000 ohms, or small such as $\frac{1}{10000}$ ohm. The answer is given in the negative, and it is stated that for low resistances like the last named it would be difficult to attain an accuracy of 1 per cent. by direct comparison with a Board of Trade Standard ohm. The author then states that by means of a properly constructed Lorenz apparatus, a resistance of 100 microhms could with ease be obtained in absolute measure to an accuracy of one part in a

thousand, and with sufficient care to probably two or three parts in ten thousand. For this reason it is advocated that the Government should possess a well-constructed Lorenz apparatus, and that the ultimate standard of resistance should be defined as the most accurate result obtainable by means of it. At present we can only say that the resistance of any particular conductor lies between limiting absolute values differing from one another by perhaps as much as four parts in ten thousand. W. G. R.

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52. *Glow in a High-frequency Field.* **H. Ebert** and **E. Wiedemann.** (Annal. Phys. Chem. 62. 1. pp. 174–181, 1897.) —The authors enclosed insulated wires and rods in exhausted bulbs placed between the terminal condenser-plates of a Lecher wire system. If a metallic rod lies parallel to the axis of the condenser, a slight evacuation suffices to show a blue glow-light against both ends of the rod on the glass surface, which spreads out in all directions, and shows figures resembling the positive forms of Lichtenberg figures. As the pressure is diminished the glow extends towards the dark centre of the rods until the ends are joined by a red bridge of light across the middle of the rod. Outside the red light is a dark space, which is succeeded by an equatorial hollow cylinder of reddish light. When exhaustion is carried still further, the various strata coalesce and the appearance begins to resemble that of a bulb without a rod in it. On substituting cylinders for the bulbs and mounting them with their end surfaces towards the condenser-plates, the ends of the rod are observed to glow at pressures as high as 50 mm., and at the same time cones of light, separated by positive glow, converge from the end surfaces towards the end of the rod. At 1 mm. pressure the glow covers the whole rod, and forms a bridge at the centre. The formation of the bridge occurs the earlier the narrower the rod. It may be retarded by using several parallel wires, or by substituting a tube for a rod of the same diameter.
E. E. F.

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53. *Voltage of an Induction-Coil.* **A. Oberbeck.** (Annal. Phys. Chem. 62. 1. pp. 109–133, 1897.)—The efficiency of an induction-coil should be specified in terms of its maximum voltage instead of its maximum length of spark. The voltage of a terminal may be investigated by attaching to it a needle-point and gradually approaching a charged conductor to it. The potential at any point from the spherical conductor is easily calculated. The distance at which the first permanent deflection of the electrometer connected with the needle-point takes place is called the critical distance, and marks the discharge potential. Measurements thus made show that for a given apparatus and interruptor the ratio of the maximum voltage of the secondary to that of the primary is very nearly constant. E. E. F.

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54. *Capillary Electrometer.* **U. Behn.** (Annal. Phys. Chem. 61. 4. pp. 748–759, 1897.)—This is an experimental test of Warburg's conduction-current theory of the capillary electrometer, which, as far as it goes, results in a verification of that theory. If it is the solution of a mercury-salt which reduces the surface tension of the mercury, this salt must be proved to exist, and its nature must be investigated. To do this, the author employed two beakers containing mercury and sulphuric acid, and joined by a siphon containing an earthenware diaphragm. A current was sent through the mercury, the liquid, and the mercury in the other vessel. A salt was actually formed, and proved to be mercurous sulphate. A quantity of this salt was then added to the kathode liquid. The same salt was then observed to be formed in the anode liquid, by solution of the anode. When the Hg_2SO_4 was added to both liquids to saturation, crystals of the substance were precipitated in the anode liquid, and mercury was at the same time deposited in the kathode vessel. The amount of mercury so deposited was 94 per cent. of the amount expected from the voltameter readings. The remaining 6 per cent. are not yet accounted for. E. E. F.

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55. *Rotating Magnetic Field.* **O. Colard.** (Écl. Électr. 12. pp. 585–591, 1897.) Continuation of the paper mentioned in Phys Soc. Abstract, No. 677, 1897.—In the former paper M. Colard discussed the case of polyphase currents on the surface of a cylinder parallel to its axis, the current through any generating line situated at angle α measured from a fixed generating line being at any instant $I \sin \alpha$. In the present paper he assumes the system of currents to consist of many sheets, the current being $I \sin M\alpha$. He finds in this case, for the radial and tangential magnetic forces respectively:

$$a_M = \int_0^{2\pi} \frac{I \sin M\alpha \sin \alpha d\alpha}{1+h^2-2h\cos\alpha},$$

$$b_M = \int_0^{2\pi} \frac{I \cos M\alpha \cos(\alpha-h) d\alpha}{1+h^2-2h\cos\alpha}.$$

Here, if R be the radius of the cylinder, H the distance from the axis of the point considered, $h=\frac{H}{R}$.

The method adopted is to find the values of these expressions for the case $M=2$; as in the former paper he found it for $M=1$; then to deduce from these results the probable general solution, and to prove that if this hold for M and $M-1$, it holds for $M+1$, and is thus established by induction.

For $M=2$, $a_2=\pi h I$ or $\frac{\pi I}{h^2}$, $b_2=-\pi h I$ or $\frac{\pi I}{h^2}$, according as the

point considered is interior or exterior. The system is then, for an interior point:

$$a_1 = \pi I, \qquad b_1 = -\pi I, \text{ (as shown in the former paper)}$$
$$a_2 = \pi I h, \qquad b_2 = -\pi I h;$$

for an exterior point:

$$a_1 = \frac{\pi I}{h^2}, \qquad b_1 = \frac{\pi I}{h^2},$$
$$a_2 = \frac{\pi I}{h^3}, \qquad b_2 = \frac{\pi I}{h^3}.$$

From which he assumes for the general formula:

For an interior point, $a_M = \pi I h^{M-1}$, $b_M = -\pi I h^{M-1}$,

For an exterior point, $a_M = \frac{\pi I}{h^{M+1}}$, $b_M = \frac{\pi I}{h^{M+1}}$,

and this is proved to be true by induction. By these means can be calculated (1) the force at any point in space, (2) the equation to the lines of force, (3) the equation to the equipotential surfaces. Finally, if the constant current I sin $M\alpha$ be replaced by an alternating infinite phased current, the magnetic field, as above defined, will turn round the axis of the cylinder with uniform velocity.

(1) The intensity of the field will be constant since it is a function of h only.

(2) The direction of the field at any point turns with uniform angular velocity M times the velocity of rotation of the plane of the zeros, that is with a frequency equal to that of the alternating currents.

(3) In the interior of the sheet the rotation is in the same direction as that of the plane of the zeros. In the exterior it is in the reverse direction. S. H. B.

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56. *Magnetism and E.M.F.* **A. H. Bucherer.** (Annal. Phys. Chem. 61. 4. p. 807, 1897.)—A correction of the author's recent paper (see Phys. Soc. Abstracts, No. 93, Feb. 1897) on the calculation of thermo E.M.F.'s, taking into consideration the external work due to evaporation and subsequent condensation. The equations acquire a form analogous to those of Kelvin, but the final result is the same as before. E. E. F.

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57. *Magnetic Screening.* **J. A. Erskine.** (Annal. Phys. Chem. 62. 1. pp. 145–157, 1897.)—A glass-hard steel needle, when magnetised, is a good test for rapid electric oscillations; they act like percussion and partly demagnetise it. The author utilises this property for measuring the screening action of metallic cylinders against the influence of a rapidly varying magnetic field, produced by the discharge of a Leyden jar fed by an influence-machine. He introduces coils of various sizes into the circuit of the condenser, and determines the demagnetising effect of each

coil upon the same steel needle magnetised to saturation. He then surrounds the needle by a screen in the shape of a glass tube covered with tinfoil, and discharges through a stronger coil so as to obtain the same demagnetising effect as before. One of the most interesting results obtained is that the screening action is almost annulled by slitting the metallic covering lengthwise. The screening action increases with the diameter and with the thickness of the tinfoil tube. The connection with the thickness is complicated, and is only approximately represented by the formula $H(1-e^{cx})$, where H is the field and x the thickness. The screening action is greatest when the first half-oscillation acts in favour of the existing magnetisation. Most of these peculiarities are easily explained by the ordinary theory of induction, regarding the tinfoil as a secondary circuit in which the induced currents tend to neutralise the variations of the field. As regards, for instance, the influence of the diameter, it must be remembered that an increase of diameter means an increase of resistance, self and mutual induction, and also an increased difference of phase.

E. E. F.

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58. *Magnetic Units.* **E. Brylinski.** (Écl. Électr. 12. pp. 591–596, 1897.)—In this second and concluding part of his paper the author gives a complete dimensional table in terms of K, L, M, T, and proposes a new system of practical units, with a corresponding new nomenclature. G. B. M.

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59. *Magnetisation of a Ring.* **J. Sauter.** (Annal. Phys. Chem. 62. 1. pp. 85–108, 1897.)—The author investigates the distribution of the magnetic flux in partially-wound rings of various dimensions and excited by various magnetising currents. One ring consisted of iron wire, the other of rings of sheet-iron. The dispersion can be represented by

$$\frac{F_{max}-F_{min}}{F_{max}}=\frac{2(M_1+M_3+\ldots\ldots)}{M_0+M_1+M_2+\ldots\ldots}\left(1+\frac{\delta}{m_{max}}\,\frac{1}{1+4\pi\kappa'}\right),$$

where F is the flux, M the magnetic moment of a section, and δ a constant introduced to correct the tangential susceptibilities according to the relation

$$\kappa=\kappa'+\frac{m}{2\pi R}\delta.$$

As regards magnetising effect in the gramme-ring, the armature current is equivalent to a homogeneous field of the strength $4Ni/\kappa$. E. E. F.

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60. *Magnetic After-effect.* **I. Klemenčič.** (Annal. Phys. Chem. 62. 1. pp. 68–84, 1897.)—The laws of the magnetic after-effect are as yet little known. In particular, the course of the after-effect within the first few seconds after making the magnetising current has not been investigated, Ewing's values beginning

5 seconds afterwards. The author has studied this question, as well as that concerning the dependence of the after-effect upon the dimensions of the magnetised rod and upon the field-intensity. To obtain some answer to the first question he used a combination of the ballistic and magnetometric methods. The rods used were of soft iron, tempered or untempered, and of steel. Their length was 50 cm. and their thickness 0·6 cm. The curves of magnetisation show that induction is very nearly complete in steel 0·0312 seconds after magnetisation, whereas an after-effect is perceptible in soft iron subsequent to that interval. The magnetic after-effect is, however, almost exclusively confined to weak fields. It decreases as the field-intensity grows, especially if the rod or iron is thin. The after-effect cannot be eliminated by strong magnetisation. Nevertheless, it is a temporary property, which is strongest just after the specimen has been raised to a red-heat, and gradually diminishes as time goes on. E. E. F.

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61. *Determination of the Ohm.* **W. E. Ayrton** and **J. V. Jones.** (Electn. 40. pp. 150–152, 1897.)—This determination is obtained by means of a Lorenz apparatus made by Messrs. Nalder Bros. for the McGill University, Montreal. The field-coil consists of 201 turns of double silk-covered copper wire, wound in a helical groove of pitch 0·025 in. on the surface of a marble cylinder. The mean outside diameter of the coil is 21·04818 in. as measured in a Whitworth machine. The diameter of the disc is 13·01997 in. and the axial length of the helix 5·025 in. From these data the calculated coefficient of mutual induction between the coil and the disc is 18037·51 in. or 45814·45 cms.

The method of making the observations is the same as that employed by Prof. Jones with the Cardiff apparatus (see Phil. Trans. 1891, A. pp. 1–42). The facility of taking readings is increased by the use of an Ayrton-Mather narrow-coil galvanometer, the data of which are as follows :—

Resistance of suspended coil	1·9 ohms.
„ „ coil and suspension ..	5·75 ohms.
Periodic time of complete swing ..	7·6 seconds.
Scale distance actually used	1412 millimetres. 1340 scale-divisions.
Deflection in divisions at actual scale-distance used	137 per micro-ampere. 23·8 per micro-volt.

The resistance-coils used were those previously employed in the Cardiff determination of the ohm.

The mean of nine determinations gives a result of 1·000294, or correcting for rate of the clock, which lost at the rate of 3 seconds in 24 hours, the result is

One Board of Trade ohm = 1·00026 true ohms.

Suggestions as to improvements of the Lorenz apparatus are then given. W. G. R

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

62. *Liquefaction of Fluorine.* **H. Moissan** and **J. Dewar.** (Comptes Rendus, 125. pp. 505–511, 1897.) A continuation of the paper of May 1897 (C. R. 124. p. 1202 ; Phys. Soc. Abstracts No. 558, Sept. 1897).—The boiling-point of fluorine is very near to $-187°$ C. At $-210°$ it is still very mobile. An interesting accident, by which air entered and was instantly liquefied, produced two layers in the tube—the upper, colourless, of liquid air ; the lower, of a pale yellow, being fluorine.

Physical Properties.—Substances of known density were immersed in the liquid, it being first ascertained that at that temperature ($-200°$) they were not attacked, if they had been previously sufficiently cooled. In one case, when this precaution had been neglected, a fragment of caoutchouc took fire on the surface of the liquid, and burnt with intense brilliancy without any deposit of carbon. It was found that wood, caoutchouc, and ebonite floated on the liquid, methyl oxalate sank, while amber remained suspended and became almost invisible. Hence the specific gravity of liquid fluorine may be taken as 1·14, and its refractive index about the same as amber. Its diminution of volume from $-187°$ to $-210°$ was $\frac{1}{14}$. In this experiment, through the accidental exhaustion of the liquid air, a violent explosion occurred, and the apparatus was reduced to powder.

Its absorption-bands could be observed in any of the specimens in a layer of 1 centim. The liquid was not magnetic. The capillarity is low, capillary tubes plunged into different liquids giving a height in millimetres of :—fluorine 3·5 ; oxygen 5·0 ; alcohol 14·0 ; water 22·0.

Action on various substances.—Hydrogen instantly combines with fluorine even at $-210°$, with great heat and light. Oil of turpentine explodes with a deposit of carbon. As a striking proof of the intense activity of fluorine, when, on several occasions, a little of the liquid was dropped on the floor, the wood caught fire.

Oxygen.—The detonating body mentioned in the previous paper was further studied. The conclusion is that this body, which is only formed in the presence of moisture, is an unstable hydrate of fluorine, although it was found that liquid fluorine did not react on water until the initial temperature of $-210°$ was raised, when an energetic action ensued under strong formation of ozone.

Mercury was not attacked at the low temperature.

Conclusions.—Fluorine is liquefied with facility at the temperature of ebullition of liquid air. Its boiling-point is near $-187°$. It is soluble in all proportions in liquid oxygen or air. It does not solidify at $-210°$. The other conclusions are embodied in the abstract. S. G. R.

63. *Densities of Liquefied Gases.* **A. Leduc.** (Comptes Rendus, 125. pp. 571–573, 1897.)—New experiments give the following densities:—

CO_2	1·5287	Cl	2·4907
N_2O	1·5301	NH_3	·5271
HCl	1·2692	SO_2......	2·2639
H_2S	1·1895		

Slight details of the modes of preparation, etc. are given.

R. E. B.

64. *Molecular Volumes and Densities of Gases.* **A. Leduc.** (Comptes Rendus, 125. pp. 703–706, 1897.)—By means of the constants referred to in the abstract of the paper on Compressibility of Gases the author has determined the molecular volumes at 0° and the densities at 0° of the gases for which the constants were determined. These he has given in tabular form in the paper.

J. B. H.

65. *Preparation of Percarbonate of Potash.* **P. T. Müller.** (Écl. Électr. 12. pp. 107–110, 1897.)—*Theory of Reaction.* If a solution of carbonate of potash, K_2CO_3, be electrolysed, it may be admitted, according to the theory of electrolytic dissociation, that ionisation takes place according to the form K | KCO_3. The anion formed by the radicle KCO_3 is directed towards the anode, and there, if suitable conditions exist, two of these radicles may combine to form the molecule $KCO_2-CO_2K=K_2C_2O_6$.

Preparation of the salt.—Electrolysis takes place in two cylindrical vessels surrounded by a freezing mixture. The central vessel is porous and contains the kathode and a dilute solution of carbonate. The external vessel contains the anode, which is of platinum (iron, nickel, copper, or silver would be rapidly attacked). During the process of electrolysis a concentrated solution of carbonate of potassium is introduced into the lower part of the anode-chamber by means of a funnel and tube; the percarbonate liquor which is formed (and in which the greater part of the new salt is found in suspension) is lighter than the solution of carbonate, and can be collected drop by drop. This is then filtered by suction, and a moist product is obtained containing 87 to 93 % of percarbonate. The output is 2·2 to 2·4 grammes of solid salt per ampere-hour. (The theoretical output, assuming no losses due to dissolution and decomposition, would amount to 3·6 grammes.) This product is then spread out on plates of porous porcelain and dried in a current of hot air. After 12 hours' desiccation the substance contained scarcely more than 6 to 8 % of moisture. Towards the end of the operation the air-temperature may be increased to 40°. A higher temperature than this gradually decomposes the salt.

The author then deals with the conditions of preparation:—If

at the commencement of electrolysis the temperature is $-15°$ and the density of the anode liquid high, then small variations of temperature produce little effect. With a decrease in the strength of the carbonate the output decreases with an increase of temperature. The concentration of the anode liquid should be as high as possible. The output is also increased by a high current-density.

Percarbonate of potassium when dry is a slightly blue amorphous powder, of a very hygroscopic nature; when damp the salt becomes bluer and gradually loses its oxygen, This salt is useful for the preparation of oxygen. When placed in water at a temperature of 45° a regular supply of gas is obtained without any application of heat, and to avoid a simultaneous discharge of CO_2 a little soda is added. Owing to its powerful oxidising properties the author considers that this salt should be of industrial use.

A. von Hansen has not yet succeeded in preparing the salts of sodium and ammonium. The manufacture of percarbonate of potassium has been patented under the title "The process of electrolytically preparing the salts of percarbonic acid" by E. J. Constam, A. von Hansen, and "Aluminium-Industrie Actien Gesellschaft," German Patent No. 91612. L. J. S.

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66. *Vapour Volumes.* **J. A. Groshans.** (Annal. Phys. Chem. 61. 4. pp. 780–789, 1897.)—The vapour volume of A grammes of a substance of molecular weight A at its absolute boiling-point B is obtained by multiplying its volume at 0° and 760 mm. by B/273. If the product is divided by the molecular volume, the vapour volume of 1 c. c. of the liquid is obtained. The molecular vapour volume is the same for all chemical bodies, and is equal to the volume of 2 g. of hydrogen at 0° and 760 mm., or 22327 c. c. Hence the vapour volume of A g. of any chemical body at its boiling-point and at 760 mm. is 22327B/273 or 81·78 B. The vapour volume of 1 c. c. is therefore obtained by dividing this quantity by the molecular volume. On applying this computation to groups of analogous bodies, it is soon seen that the vapour volume is nearly the same for all bodies of the same group. For benzol and the phenyl haloids it is approximately 290. E. E. F.

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67. *Electrolytic Analysis of Bronzes and Brasses.* **A. Hollard.** (Écl. Électr. 12. pp. 127–129, 1897.)—The author gives the details of processes for the accurate and easy estimation of copper, tin, zinc, etc. entering into the composition of bronzes and of brass. The subject is classed under the following headings:—

I. *Bronzes.—Estimation of copper* (electrolysis in acid solution). (See also C. R. vol. 123. p. 1003; Écl. Électr. vol. 9. p. 557, Dec. 1896.) Electrolysis is performed according to the methods indicated in the following articles:—C. R. vol. 123. p. 1003; Écl. Électr. vol. 9. p. 557, Dec. 1896.

Estimation of tin (electrolysis in hydrochloric solution with the addition of ammonium oxalate). The use of oxalate of ammonium for the electrolysis of tin has already been published by M. Classen,

who recommends, however, working with as neutral a solution as possible. The author has found that under such condition the bath may become disturbed during electrolysis, owing to the formation of insoluble compounds of tin.

Estimation of tin by electrolysis. This process is somewhat similar to the method due to M. Riche (C. R. vol. 135. p. 226).

II. *Brass.*—The estimation of copper is performed according to the method for analysing commercial copper (see C. R. vol. 123. p. 1003, and Écl. Électr. vol. 9. p. 557, Dec. 1896). The estimation of zinc and impurities is performed according to the above processes. L. J. S.

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68. *Mutual Diffusion of Electrolytes.* **U. Behn.** (Annal. Phys. Chem. 61. 1. pp. 54–67, 1897.)—The author describes some experiments made to determine the number of ions passing across the surface of contact between two homogeneous dilute solutions of binary electrolytes. The two solutions were placed one over the other, with a free contact-surface about 5 mm. in diameter, across which diffusion took place. Such experiments were made with dilute solutions of HCl and LiCl, or HNO_3 and $AgNO_3$. The surface was made small in order to keep the two solutions sensibly homogeneous, and the duration of each experiment was one or two weeks. It was found impossible to get rid of convection altogether, and so the intrusion of ions from the opposite solution could not be confined to the immediate neighbourhood of the contact-surface. But distinct evidence was obtained of diffusion against the concentration gradient in cases where the electrostatic attraction surpassed the osmotic pressure, as foreseen by Nernst's theory. E. E. F.

GENERAL ELECTRICAL ENGINEERING.

69. *Testing Storage Batteries.* **R. Kennedy.** (Elect. Rev. 41. pp. 821–822, 1897.)—Reports on the tests of storage-cells are frequently very misleading, on account of the comparisons which are sometimes drawn between cells whose discharge rates per pound of plates are very different. A comparison of two types of secondary cells can only be fairly made by adopting the same rate of discharge per pound of plates. If a curve be drawn, for a given type of cell, connecting the pounds per kilowatt-hour of the cell with its rate of discharge in amperes, it will be found that the former quantity falls at first very rapidly, then more slowly until at about 100 amperes it becomes a straight line. Hence a comparison of two cells whose rates of discharge are very different is of no value whatever. A. H.

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70. *Electrically-operated Electric Engine-room Telegraph.* **C. Arldt.** (Electrotechn. Ztschr. No. 32. pp. 487–490, 1897.)—This apparatus, which was originally designed by Dr. L. Weber, of Kiel, and is constructed by the Allgemeine Elektricitäts-Gesellschaft, comprises a switching device whereby a magnetic field in the receiver turns synchronously with the lever of the transmitter, so as to produce a perfect rotary field. In this rotary-field indicator, the transmitter consists of an annular resistance-coil closed on itself and divided into sections each of which is connected to a bar of a circular commutator, over which moves a lever having a sliding contact-piece at each end. These sliding-contacts are adapted to engage with diametrically-opposite bars of the commutator, and are each connected, through sliding-brushes and fixed contact-rings, with terminals to which current is supplied from any suitable source. To three of the commutator-bars, at 120° apart (for which purpose the number of bars must be divisible by three), are connected conductors leading the current to the receiver. This receiver consists of a system of three (or a multiple of three) similar magnet-coils arranged with their axes at 120° apart around a pivoted arbor which carries a magnet and a pointer moving over a suitably-marked scale. The inner ends of these coils are connected together, whilst their outer ends are each connected to one of the conductors from the transmitter.

Assuming now, for illustration, that the transmitter and receiver are arranged so that the axes of the magnet-coils in the receiver are parallel to radii joining the centre of the commutator to the points of connection of the three conductors, and the lever carrying the contacts is placed with one contact over one of these points of connection, and the other contact midway between the other two of these points. When this is so, it is obvious that the

inner pole of the magnet corresponding to the point of connection on which the sliding-contact rests, will be, say, of S polarity, whilst the inner poles of the other two magnets will be of N polarity, and consequently the N-pole of the magnet on the pivoted arbor will be attracted towards the magnet-coil whose inner end is of S polarity, whilst its S-pole will lie midway between the other magnets whose inner ends are of N polarity. It follows that the pointer will turn through 180° when the contact-arm is turned through a like angle, and that the results will be similar, in whichever of the three main positions the contact-arm is placed, and that the contact-arm and pointer will also remain parallel to each other for intermediate positions, since the currents along the three conductors and magnet-coils will vary regularly approximately according to a sine law, there being a difference of phase between them of 120°. The number of signals transmitted may be very large; for example, it is possible to so arrange the apparatus that it will indicate accurately from degree to degree, so that 360 separate signals can be transmitted.

When used for an engine-room telegraph, each transmitter is preferably combined with a receiver, so that when the indicator-arm on the bridge has been set to any position, the order can be acknowledged by the engineer in the engine-room by setting his transmitter to the same position; thus both the arm of the transmitter and the pointer of the receiver on the bridge will be on the same division of the dial. A bell can be rung automatically when the indicator-arms are moved.

When used as a water-level indicator, the contact-arm in the transmitter can be mounted on a spindle bearing a sprocket-wheel over which passes a chain connected to a float. The indicator can also be employed for a number of other purposes. C. K. F.

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71. *Rubber and Compound Insulation.* (Elect. Rev. 40. pp. 521–522, 1897.)—The writer briefly refers to the various materials used for insulating cables, and states it as his opinion that, in spite of their high initial cost, rubber cables will in some cases always continue to be used. Impregnated or absorbent dielectrics have one marked peculiarity which is sometimes an advantage—they generally give warning of a developing fault, so that the latter may be located and the faulty section of cable withdrawn before there is an actual breakdown. An insulator known as "silex" has recently come into vogue in the United States; it consists of pulverised rock, and is commonly used in the form of powder, being packed round a bare conductor set in an iron pipe. It is non-hygroscopic, non-inflammable, cheap and durable. The writer refers to sudden breakdowns caused by rises of P.D. on account of electrical resonance, and mentions some methods used for preventing such breakdowns. A. H.

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72. *Diatrine for Cables.* (Elect. Rev. 40. pp. 379–380, 1897.) —The article gives an account of some tests of a new rubber-like non-hygroscopic insulating material recently introduced by Messrs. Glover & Co., and by them called "diatrine." It is claimed for this material that it combines considerable mechanical strength and flexibility with high insulation resistance and dielectric strength. The tests given bear out the truth of this statement. The material is said to be very cheap. Its durability has still to be proved. A. H.

DYNAMOS, MOTORS, AND TRANSFORMERS.

73. *Dynamo for Three-Wire Distribution.* **M. Aliamet.** (Elect. Rev. 40. pp. 95–97, 1897.)—In feeding a three-wire network, it is an advantage to be able to use large units instead of groups of two smaller units coupled in series, as was done in the earlier plants. Various devices have been suggested and used from time to time in order to admit of the use of larger generators. One of the earliest consisted in the use of a battery of secondary cells coupled direct to the generator, the middle point of the battery being in connection with the neutral wire. Another plan is to provide the armature with two independent windings and commutators. Dobrowolski's method is to connect a reactance-coil across two insulated collars connected to diametrically opposite points in the armature winding, and to join the middle point of this coil to the neutral wire. There are disadvantages attending the use of all the above methods. A much better plan is one due to Müller, who places a third brush halfway between the main brushes, and connects this to the third wire. In order to prevent the destructive sparking, which would result in the case of an ordinary two-pole machine with this arrangement, Müller splits each pole into two parts separated from each other by a neutral zone in which the intermediate brush is placed. The machine has thus the appearance of a four-pole generator, although in reality it is only a two-pole one. In order to allow of the independent regulation of P.D. on the two sides of the three-wire network, the windings of diametrically opposite pole-pieces are joined in series, one set of windings being connected between the +brush and the intermediate one, the other between the latter and the −brush. A. H.

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74. *Series Winding of Compound Dynamos.* **L. H. Fry.** (Elect. Rev. 41. p. 540, 1897.)—Two cases are considered: (1) A dynamo which has already been built and provided with the necessary shunt-winding; (2) a dynamo not yet built and for which only the drawings and calculations are available. In the first case the author uses Fröhlich's formula to find the additional ampere-turns to be provided by the series-coils (the two constants of the formula and the drop due to armature resistance and reaction having been determined by experiment). In the second case, he first obtains the series turns required to compensate for drop due to resistance; and then uses Dobrowolski's construction for finding the turns required to balance armature reaction (in which the ampere-turns required to develop the E.M.F. on open circuit + those required to balance armature reaction are taken as the hypotenuse of a right-angled triangle, whose sides represent the armature ampere-turns and the resultant ampere-turns respectively). A. H.

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75. *Equalising Connections for Compound-wound Dynamos.* **E. R. Keller.** (Elect. Rev. 40. pp. 540–541 and 555–556, 1897.)—The author discusses the action of the "equaliser" connection, first suggested by Gramme for series machines, and by Mordey for compound. The device consists in joining in parallel the brushes of all the machines which are working in parallel. The primary function of the equaliser is to prevent a possible reversal of polarity of any machine whose E.M.F. happens to fall below the normal value. It also assists to some extent in equalising the distribution of load among the various machines. The author works out the expressions for the currents in the various parts of a circuit fed by two compound machines working in parallel, and by considering a special case shows that the current carried by the equaliser may reach a high value. The currents in the series-windings are equalised the better, the lower the resistance of the equaliser. The author suggests a modification of the usual method of arranging the connections: he proposes to use an extra bus-bar, to which one end of each series-winding is permanently connected; the other end is connected through a single-pole switch to the corresponding bus-bar. A two-pole switch enables the armature of each machine to be connected between the remaining bus-bar and the auxiliary one connecting the series-windings. The resistances of the connections are so proportioned that the drop of potential from the brush of each machine through its series-winding to the bus-bar is the same for all. The currents in the series-coils of the machines will then be proportional to their capacities. A. H.

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76. *Automatic Regulator for Dynamos.* **F. Collischonn.** (Elektrotechn. Ztschr. No. 25, pp. 357–359, 1897.)—The author first gives a short sketch of the various types of automatic regulator already designed, and then proceeds to describe his own. The principle of this regulator is as follows:—In parallel with the dynamo are arranged two electromagnets which are each provided with an armature adapted to be pulled away therefrom by a spiral spring. The pull of these spiral springs is so adjusted that, when the P.D. between the terminals of the dynamo is normal, one of the armatures will be held away from its magnet, whilst—likewise at the normal P.D.—the second armature will not be pulled away from its magnet by the spring. From this it is obvious that the first electromagnet only acts when P.D.'s occur which are higher than the normal, whilst the second is only influenced by those which are below the normal. The circuit of the first electromagnet is provided with an interruptor in a similar manner to the electromagnet of an electric bell so that, when the current in its coils reaches a certain value, the armature will begin to vibrate, this action continuing until the P.D. falls to the normal. To produce vibration of the armature of the second electromagnet, when the P.D. falls below the normal, its circuit is permanently connected

across the dynamo terminals, and an auxiliary circuit, in parallel with the other and containing the interruptor, is provided for producing the vibration. This vibratory motion of the armatures is utilised to rotate a metal ring turning on a series of rollers, in one or the other direction accordingly as one or the other armature is vibrating, this being effected by providing suitably-arranged pawls on the ends of the said armatures for engaging with a series of teeth formed on the periphery of the said ring. This ring is provided with a series of iron pins, mounted in but insulated from the ring and connected to a series of resistances which are gradually introduced or cut out of the field-magnet circuit of the dynamo as the ring rotates in one direction or the other, this being effected by means of a small quantity of mercury which remains in the lowermost part of a channel formed in the interior of the ring. These regulating resistances can either be mounted on the frame of the apparatus and be connected to the pins by means of flexible conductors, or they may be embedded in enamel on the ring itself. A commutator in connection with a series of resistances is also provided for enabling the apparatus to work at different P.D.'s. The apparatus is capable of maintaining the P.D. within 0·5 per cent. of the normal, and can also be used with alternating currents. C. K. F.

77. *Starting Monophase Induction Motors.* **R. Arno.** (Écl. Électr. 13. pp. 390–395, 1897.)—The method described consists of:—(1) Inserting, during the first moment of starting, a resistance of a proper value in each elementary winding of the rotor; this is chosen so as to make the whole resistance of the corresponding circuit slightly less than $2\pi n L$, L being the inductance of the circuit, and n the frequency of the current.

(2) Impressing on the rotor a very small initial velocity, such as is maintained by rotating the pulley by one quarter turn, or giving a pull to the belt.

(3) Reducing the additional resistance to nothing as the maximum speed is attained.

Tests on three motors of 12, 25, and 110 H.P. respectively seem to show that when started in this way, the starting-current is much the same as the full load current, which is a great recommendation, since monophase induction-motors started by means of an initial rotary-field often require four or five times their full-load current at starting. W. G. R.

78. *First Cost of Transformers.* **G. Adams.** (Electn. 38. p. 112, 1897.)—The transformers considered are all of the closed magnetic circuit type, and built for outputs varying from 3 to 10 kilowatts. The frequency of the supply-current is taken as 100; the induction in the core as 3500 lines per square centimetre; the primary potential difference 2000 volts; the secondary potential difference 100 volts; the price of copper 10*d*. per pound, and the price of iron as 4*d*. per pound. The following table is given:—

Output in kilowatts.	Secondary Turns.	Primary Turns.	Weight of Copper in lbs.	Weight of Iron in lbs.	Cost of Copper.		Cost of Iron.		Total Cost of Iron and Copper.		Efficiency per cent.	Primary Current in amperes.	Secondary Current in amperes.	Iron Loss in watts.
					s.	*d.*	*s.*	*d.*	*s.*	*d.*				
3	20	392	16	246	13	4	82	0	95	4	94·2	1·5	30	123
3	30	588	20	160	16	8	53	4	70	0	95·6	1·5	30	80
3	40	785	37	130	30	10	43	4	74	2	95·1	1·5	30	65
6	20	392	31	282	25	10	94	0	119	10	95·8	3	60	141
6	30	588	56	218	46	8	72	8	119	4	96·4	3	60	109
6	40	785	77	152	64	2	50	8	114	10	96·8	3	60	76
6	50	980	109	109	90	10	36	4	127	2	97·1	3	60	545
10	15	294	32	435	26	8	145	0	171	8	95·0	5	100	217
10	20	392	44	309	36	8	103	0	139	8	96·0	5	100	154
10	30	588	96	214	80	0	71	4	151	4	97·0	5	100	107
10	40	785	160	208	133	4	69	4	202	8	97·0	5	100	102

W. G. R.

79. *Constant Speed-Motors.* **W. Baxter.** (Elect. World, 30. pp. 633–636, 1897.)—This paper contains the following practical directions for ascertaining the field-winding of a differentially-wound constant-potential motor. Using an experimental coil on the field-magnet, adjust the exciting current until the required speed is obtained, the motor running light. Next, put on the full load, and reduce the exciting current until the same speed is reproduced. From the number of turns on the exciting coil and the current, we at once obtain the ampere-turns to be provided by the shunt and series coils respectively. A. H.

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80. *Speed-Regulation of Motors.* (Elect. Rev. 40. pp. 31–32, 1897.)—The article refers to a method of controlling the speed of direct-current motors, proposed by H. W. Leonard in a paper read by him before the American Institute of Electrical Engineers in Nov. 1896. This method consists in placing a rheostat in the field circuit of the *generator.* The author examines the advantages and disadvantages of this method as compared with the ordinary one of placing a resistance in series with the motor armature. In the latter case, the load must be tolerably constant, or else the motor will run by a succession of jerks; also, if it is desired to run at full load much below the normal speed, the power required is the same as at full speed. The new method does away with both these difficulties. On the other hand, it is not applicable in cases where the E.M.F. of the generator has to be maintained constant. The author thinks that when the field of the generator is weakened beyond a certain point, there may be serious difficulties on account of excessive sparking.

[In a letter to the Elect. Rev. of Jan. 15th, 1897, Mr. L. B. Atkinson states that the above method has been in use since 1893 in a large electrical haulage plant (130 H.P.) at the Trafalgar Collieries in the Forest of Dean, and, with carbon brushes, has given excellent results.—*Abstractor.*] A. H.

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81. *Setting up Large Generators.* **G. T. Hanchett.** (Elect. World, 30. pp. 665–667, 1897.)—The armatures of large multipolar generators are either lap-wound or else wave-wound. The latter winding is mainly used in high-voltage machines (500 volts or more), the former in low-voltage ones. If a wave-wound armature gives trouble on account of excessive heating caused by a local current, this can only be due to some defect in the armature itself, for any want of symmetry in the field would affect the two armature circuits equally. With a lap-winding, however, the armature may be perfect, and yet the machine may refuse to work satisfactorily, some sections of the winding carrying more current than others, or a section of high voltage supplying current to one of low voltage, thus driving the latter as a motor (this latter action is called "bucking"). Such troubles may be caused by: (1) the field poles not being magnetised to the same intensity; (2) the

armature not being truly concentric with the field. By connecting an ammeter in series with any brush, it is not difficult to ascertain whether the corresponding section of the armature carries its fair share of the load. Difficulties arising from unequal magnetisation of the poles are generally due to unequal ampere-turns on the exciting coils, and may be caused by a defect either in a shunt-coil (in which case the armature will heat when running on open circuit), or in a series-coil (when there will be a tendency to "bucking" at full load). A very simple method of finding the defective coil consists in separately exciting the machine and ascertaining the fall of potential over each coil; if the coils are wound with the same size of wire, they should have approximately equal resistances.—In setting up large generators, the field is generally adjusted in position by means of a taper-gauge, the same clearance being allowed between each pole-piece and the armature. In most cases this yields satisfactory results, but a further adjustment may be necessary. The field having been aligned as far as possible by means of the taper gauge, the machine is excited, and the E.M.F. contributed by each section is ascertained. If the E.M.F.'s so obtained are plotted at equal angular distances in a polar diagram, and if the diagram exhibits symmetry, any want of equality is due to lack of alignment, and the defect is easily remedied; but if the diagram is distorted, then in all probability the defect lies in one of the exciting coils. The accurate adjustment of the field is a very tedious process, as the field has to be rigidly bolted down after each change of position; the adjustment is, however, made once for all, and then the relative position of the field and bed-plate is marked in two places with a cold chisel.

When a defect has to be remedied and the type of armature-winding is unknown, it may be ascertained in some cases by noticing the relative direction of the end-connectors. Frequently, however, these are covered with canvas, and the best plan then is to send a small current through the armature, and by means of a low-reading voltmeter ascertain the P.D.'s between one of the brushes and all the points where brushes might be placed with a lap-wound armature. From the voltmeter readings the nature of the winding may be inferred. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

82. *Life of Incandescent Gas Mantles.* **E. A. Medley.** (Elect. Rev. 41. pp. 824–826, 1897.)—The author gives the results, in the form of curves, of careful tests of various incandescent gas-mantles. These show that in all cases there is a rapid falling-off in light-giving power (in some instances, however, a slight initial rise is observed). Most of the mantles exhibit a deterioration of from 40 to 60 per cent. of their initial candle-power after 500 hours' use. The best results are obtained with the "Stabil" mantle, of German make, which after 500 hours' use retains about 75 per cent. of its initial candle-power. A. H.

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83. *Recent Progress in Arc Lighting.* **E. Thomson.** (Elect. Rev. 41. pp. 94–95 and 103–104, 1897.)—This paper deals with the various systems of arc lighting, and their relative efficiencies. Recently, machines capable of feeding 125 to 150 arc-lights in series, with a P.D. of 7000 volts between terminals, have been successfully employed. The author considers that for extended districts the series arc-lighting system will still hold its own; it involves a simple system of wiring, and is best adapted to the use of the cheaper carbons. In cities supplied with underground distributing mains, very good results are obtained by joining the lamps in parallel across the mains—a steadying resistance which absorbs a good deal of power being necessary. Enclosed arcs are coming largely into use; the P.D. may in this case be as much as 80 volts. The arc is long, and the ends of the carbons remain flat. The life of the carbons is very long, and hence there is an important saving of carbon and labour. The carbons must be of the very highest grade of purity, not too hard or dense. A thin deposit, nearly white in colour, is obtained on the inner enclosing globe; this is wiped off when re-carboning the lamp. Alternating arcs are next considered. Owing to the periodical extinction of the arc, an alternate-current lamp is liable to "chatter" when first switched on, before the carbons have been heated up. The lower limit of frequency is about 40. Owing to their hum, alternate-current arcs are not suitable for indoor lighting. They seem to burn best with soft carbons furnishing a considerable amount of volatile matter. Although inferior to continuous arcs as regards luminous efficiency, they appear to be quite stable, so that no resistance or reactance is required when running off constant potential mains; this, to some extent, makes up for their inferior luminous efficiency.—The efficiency of arcs increases with their size; thus, naked arcs, with 10 amps and 48 volts, may take for each mean spherical candle-power 1·2 watt, while arcs of 7 amps and 48 volts require 1·4 watt. A $4\frac{3}{4}$ ampere enclosed continuous-current arc ($\frac{1}{2}$ inch carbons) with clear inner and no outer globe takes 1·94 watts per mean spherical candle-power. A 16-

ampere 25-volt naked alternating arc is found to take 1·49 watts per mean spherical candle-power; an enclosed arc taking 2 watts. A. H.

84. *Leading-in Wire for Incandescent Lamps.* **S. Cowper-Coles.** (Elect. Rev. 41. pp. 923–924, 1897.)—The author deals with the question of the cost of platinum for incandescent lamps, and estimates this at from $\frac{1}{2}d.$ to $1d.$ per lamp. He then gives an account of the various attempts which have been made from time to time to obviate the use of platinum. A. H.

85. *Alternating Current Arc Lamp.* **M. Aliamet.** (Électricien, 14. pp. 369–370, 1897.)—The chief feature of this arc-lamp is the regulating arrangement, which consists of a copper disc whose edge passes between the poles of two electromagnets, one of which is in series with the arc and the other in parallel with it. Co-axial with the copper disc is a pulley round which passes the cord to which the carbon holders are suspended. When the carbons are in contact only the series-coil acts, and the copper disc acting as an induction motor rotates in such a direction as to pull the carbons apart, and when the carbons are far apart the parallel electromagnet acts, and the disc rotates so as to bring the carbons together. W. G. R.

86. *Schuckert & Co.'s Arc Lamp.* (Elektrotechn. Ztschr. No. 32. p. 495, 1897.)—This lamp (German Patent, No. 90945) comprises a rocking-frame carrying a train of wheels having, on the first arbor, a drum connected to the movable carbon-holder by a cord or wire, and, on the last arbor, a brake-wheel adapted to engage with one arm of a weighted lever which normally rests against a stop in a definite position. The rocking frame rests on horizontal racks by means of toothed wheels so that, as it rocks, it moves laterally, and thus the motion is made smoother by doing away with an axis turning in stationary bearings. To control the motion of this rocking frame, it is provided at its ends with curved surfaces engaging with rollers mounted on the cores of the regulating solenoids. C. K. F.

87. *Arc Lighting with Rectifiers.* **C. D. Taite.** (Electn. 39. p. 374, 1897.)—In this article the use of rectifiers is advocated, because of (1) the efficiency, (2) the small upkeep, and (3) the small floor-space required. At Southport, where forty-three arc-lamps are seen in series, the input of the rectifier averages 33 units per hour and the output $30\frac{3}{4}$ units, giving about 93 per cent. efficiency at full load. At half-load the efficiency is 87·4 per cent. The upkeep of the rectifier is only 2·35 per cent. of the gross income from the lamps. W. G. R.

88. *Suspension for Arc Lamps.* **H. Rentzsch.** (Elektrotechn. Ztschr. No. 29. pp. 419–420, 1897.)—An improved form of windlass is described with sliding contacts for use in raising and lowering arc-lamps. It consists of a base-plate carrying insulated terminals and also a fixed hollow shaft on which turns a disc forming one side of a flanged drum for receiving the flexible conductors leading to the arc-lamp, the remaining part of this drum being detachably secured to the said disc and having at its other end a journal turning in a bearing formed in the removable cover of the apparatus. The hollow shaft is provided with two insulated contact-rings arranged at its free end within the rotary drum connected to the terminals by insulated conductors passing through the passage in the interior of the shaft. In the interior of the drum are mounted insulated brass pillars carrying brushes which are adapted to engage with the contact-rings on the hollow shaft, these pillars having clamps to receive the insulated conductors leading to the lamp. The drum is also provided with a spur-wheel adapted to engage with a pawl or detent on the base-plate so as to enable it to be locked in any desired position; the drum is turned by means of a detachable crank-arm having a squared end fitting into a square hole in the journal on the removable part of the drum. To attach or dismount the conductors, the cover and detachable part of the drum can be removed and access thus obtained to the connections. C. K. F.

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89. *Power Factors of Electrical Plants.* **R. Klasson.** (Electn. 39. pp. 319–320, 1897.)—This article describes some experiments made on the effect of synchronous motors or rotary converters on the power factors of electrical plants. If the load consists partly of induction motors, a highly synchronous motor or rotary converter has the effect of increasing the power factor, and the author considers that it is advantageous to overexcite rotary converters when running on light load, since for a given output the current in the transmission mains is thereby diminished and the necessary capacity of the generating plant correspondingly diminished.

W. G. R.

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90. *A* 10,000 *Volt Transmission Plant.* **W. Klug.** (Electn. 38. pp. 469–472, 1897.)—This is a description of the three-phase plant between Eichdorf and Grünberg. The power is developed at a voltage of 225, transformed up to 10,000 at Eichdorf, and down to 120 volts at a single step at Grünberg. The transmission mains consist of bare copper wire 25 sq. mm. in section in the intervening country, and of the same size of india-rubber insulated wire when entering the towns. The lines are throughout protected by lightning-protectors—one for each line wire. The spark-gap is between bent copper strips held on high-pressure insulators. The line is connected to one of these strips and the other is connected to earth. As a further protection from lightning, a

barbed wire runs above the line, being fixed to the tops of the poles and earthed at every sixth pole. Experience shows that this system of protection from lightning is efficient. W. G. R.

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91. *Jungfrau Electric Railway.* (Écl. Électr. 13. pp. 25–27, 1897.) —This article includes a table stating the details of the line. The line proper commences at the Scheidegg Station as a branch to the Wengernalp Railway. At the Mœnch Station there will be a crossing for the ascending and descending trains. The first section from Scheidegg to the Eiger Glacier is now almost completed. The tunnel commences about 2·5 km. from the starting point and extends, with few interruptions, to the summit. The power is obtained from the two branches of the Lutschine at Burglauenen and Lauterbrunnen. Tests show that in one locality 9000 H.P. are available, and in the other branch 2130 H.P. At the latter, the Lauterbrunnen station is being installed. The output will be 500 H.P., being sufficient for traction on gradients of 25 % at speeds of 8·5 kilometres per hour, and also for supplying power for heating and lighting. The power at the axles of a train, with a load of 26 tons, will be 211 H.P., and the total working efficiency 50 %. The stations are to be lit from batteries of accumulators charged *in situ*. During construction the current will be employed for working drills and cooking apparatus.

The Lauterbrunnen station will be capable of supplying 2130 H.P. for driving four trains simultaneously. The provisional station consists of two turbines of 500 H.P., and two turbines of 25 H.P. for driving exciters. The large turbines are of the Girard type with horizontal axes, and governed for the large variations of load on the line. The small turbines are also fitted with automatic regulators. The total cost of the Lauterbrunnen installation amounts to 558,800 francs, or 260 francs per H.P. The majority of the schemes submitted were for the 3-phase system. Each turbine is direct coupled to a 3-phase generator running at 380 revs. p. m., and working at a frequency of 38 $\sim$ and 7000 volts.

The contract stipulates that the inhabitants of the Commune of Lauterbrunnen are to receive, free of charge, 50 H.P. for the whole year, this power being supplied at a pressure of $\frac{7000}{\sqrt{3}}$ volts by one of the phases. The primary conductors run to the Scheidegg station, where the pressure is reduced to 500 volts.

The line consists of three hard-drawn copper wires, 7·5 mm. dia., which are run up to an altitude of 1300 metres. The secondary line runs overhead as far as the entrance of the tunnel; it consists of copper wires 9 mm. dia., supported by span wires. The same posts carry telephone wires and the test lines. The conduit system to be used in the tunnel has not yet been decided upon.

Twelve transforming stations are placed along the line. One is specially designed for working the lift; the others are spaced 1 km. apart on gradients of 25 %, and 1·75 to 2 kw. along gradients of 10 to 15 %. The trains will follow one another at intervals of 1 kilometre or 7 minutes, the stoppage at the crossing-point will be 20 minutes. This crossing station is connected to the line by a lateral tunnel several hundred metres long, and along which will run a light car.

The trains will consist of a locomotive and of a trailer car. The weight of the locomotive alone is 12 tons. The 125 H.P. motor used on the locomotive runs at 800 revolutions, and this maximum power of 125 H.P. corresponds to a current of 235 amperes per phase on the secondary line.

The gauge of the line is 1 metre, and the two pinions gearing in the rack are 70 cm. dia. each, the maximum force at the teeth is 6500 kilos, and the diameter of the wheels 60 cm.

The locomotive is fitted with the following brakes:—(1) On the axle of the dynamo is an electric brake which comes into action when the supply-current ceases. An electric regulator is combined with this brake to switch off the current should the speed become too great. The switch can also be operated by means of a cord fixed outside the car. (2) A hand-brake, consisting of levers and bronze shoes acting on the motor pinions. (3) A brake grip, the bronze shoes of which act on the lateral faces of the rails; this brake may be employed for regulating the speed on descending.

The carriages have an actual weight of 2000 kg., and can carry 8000 kg., the ratio of dead to useful weight being 32 %.

The author will publish further data when the line is more advanced. L. J. S.

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92. *Electric Lighting of Vehicles on the Jura-Simplon Railway.* **C. Jacquin.** (Écl. Électr. 12. pp. 552–562, 1897. See also Écl. Électr. Aug., p. 392; and La Lumière Électrique, 1894.)—At the beginning of 1894 electric light had been applied to all the trains on this line, it became a difficult matter to charge all the batteries from the Fribourg station. The Jura-Simplon railway therefore took advantage of the large hydraulic station which had been erected at Bienne in 1893; they made this a second charging centre for their batteries. A substation was installed as at Fribourg, serving for lighting purposes as well as for charging accumulators. The central station at Bienne was installed by the firm of Lahmeyer of Frankfort, and obtains its power from a 50-metre water-fall driving two turbines of 250 H.P., each working two 3-phase generators of 65 kw. each. The power at 80 volts provided by the generators is transformed in the station to a pressure of 1800 volts, and is then sent through two primary circuits consisting each of 3 bare copper wires.

One of the lines, 2·1 km. long, with wires ·6 mm. dia., extends to the Jura-Simplon works 1 km. from Bienne, and is there connected to a rotary converter, running as a 3-phase

synchronous motor, and which itself is used for power purposes as well as for supplying current at 110 volts for lighting. This machine converts 90 kw., 50 to 60 H.P. of which is supplied as motive power and the remainder for lighting.

The second primary line, which is 3·2 km. long, consists of 3 copper wires 7 mm. dia., and supplies 130 H.P., half of which is for the station at Bienne and the other half for lamps and motors in the town. Lahmeyer converters being here used for distribution at 120 volts. These converters consist of a rotating-drum armature and of a single coil 8-pole field. The armature on one side carries three collector-rings for the high-tension current and a commutator on the other side. The high-tension winding is placed in slots in the armature, and the low-tension winding over this. The two windings are separated by a copper earth-shield. The converters, as in the case of synchronous motors for polyphase alternating currents, can start alone. If the field be unexcited and the continuous-current side disconnected, and the high-tension side alone be closed, the motor will run up to speed owing to reactions on the pole-pieces, and under these conditions will have an appreciable torque. The converter can be started in this manner in two minutes. The converters are under some conditions started as shunt-motors from the continuous-current side, in which case a phase-indicator has to be employed. A part of the continuous current passes to twelve battery-charging circuits. The batteries are removed from the railway-carriages for charging purposes. The original cost of maintenance of 650 batteries, as contracted for by the Société de Marly, varied from 23 to 25 francs per battery. The Company then undertook the maintenance of the batteries themselves.

The arrival and departure of all the accumulator boxes is recorded in a register. When fully charged, the voltage of 9 cells must not amount to less than 19 volts. The batteries are enclosed in three-chamber ebonite boxes protected by an outer wooden case. As in Switzerland the trains do not run after midnight, the batteries can be completely recharged in 9 hours. There are 425 batteries in use and 250 batteries kept as a reserve. The lamps, owing to their low voltage, cost $2\frac{1}{2}$ francs each, and their life varies from 300 to 600 and 700 hours.

The central stations mentioned above supply power by meter at the low rate of 0·05 franc per H.P. hour, or 0·067 franc per kilowatt-hour. A single battery supplies current to four 10-candle-power lamps for 1000 hours each year; and the total cost of maintenance amounts to only ·0031 franc per lamp-hour of 10 candles.

Taking into account the efficiency of converters and accumulators, the expenditure of 30 watts for a 10-c.p. lamp is very low as compared to the price of gas or oil. The Jura-Simplon railway is, however, acknowledged to be working under exceptionally favourable circumstances. It may be said that the greater the railway system the greater the cost of electric lighting.

The author concluded by the statement that when the applications of electric lighting are restricted to particular cases possessing favourable conditions of working such as the above, then many difficulties are eliminated, and this mode of lighting may then well compete with the other systems. L. J. S.

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93. *Electric Railway Traction.* **C. T. Child.** (Elect. World, 30. pp. 443–448, 1897.)—The author discusses the possibilities of electric traction on the Philadelphia local railway-lines. A 3-phase transmission at 5000 volts is recommended, coupled with sub-stations, where the energy would be transformed into direct current at 750 volts, the distribution being effected in conjunction with a storage battery and a booster at each sub-station, so that the load on the central station is maintained practically constant. The main points of the system are considered, and an estimate given of the capital outlay and working expenses. W. R. C.

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94. *Electric Traction.* **G. Pellissier.** (Écl. Électr. 13. pp. 309–313 & 349–357, 1897.)—The author gives an account of various appliances and systems of electric traction, of which the following is a brief summary :—

In the device of E. C. Parham for extinguishing arcs in controllors a separate magnet is employed for each contact, instead of one electromagnet as used by Elihu Thomson, thereby effecting an economy in the necessary current. The automatic mechanism of H. F. Parshall for preventing the speed of a car exceeding a given value is described, and also the electric brake manufactured by the Union Elektricitäts-Gesellschaft. The Heilmann system has been applid by Patton to tramcars with good results. The car carries an oil-engine, a dynamo, a battery of accumulators, and one or two motors. It was used in conjunction with from one to five trailer trucks. The consumption of gasoline amounted to 15 gallons per day of 10 hours (no figures are given as to weight, etc.). A somewhat similar car is due to L. H. Nash : this carries no battery, but an increased current for slow speed of motors is obtained by means of a differential winding. Allusion is made to the method of Snell, Grove, and Hills for the working of automatic commutation of current on crossings where a three-wire system is employed ; and an account is given of the Lachmann mechanism for the commutation of current where a single-trolley wire is used in place of two wires, and is divided into alternate + and — sections. Max Déri surmounts the difficulties experienced in using alternate-current motors upon cars by employing a subsidiary direct-current motor and battery of accumulators to be used for the purpose of starting only. In Meacock's system of distribution the conductor is surrounded by indiarubber and is placed in the groove of the rails. The rubber case consists of two parts, forming

two longitudinal joints, which are normally closed. In the upper one of these a metallic blade attached to the car slides and makes the necessary contact. A somewhat detailed description is given of the conduit and surface systems of C. F. de Redon, of C. F. P. Stendebach and O. H. Linker, of Demeuse, and of Adamson.

The paper concludes with a brief account of J. Steffen's station indicator, and of André and Silbermann's method of working switches from a car. W. R. C.

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95. *Electric Traction in Brussels.* **M. Travailleur.** (Écl. Élect. 13. pp. 434–443, 1897.)—The author gives an account of the conduit tramway system recently laid down in Brussels.

W. R. C

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96. *Accumulator Traction at Ostend.* **E. Piérard.** (Électricien, 14. pp. 305–308, 1897.)—The cars are constructed to carry 50 persons, with seats (inside only) for 24. The weight, unloaded and without accumulators, is $7\frac{1}{2}$ tons. That of the accumulators is not given; but it is to be inferred that the weight somewhat exceeds $2\frac{1}{2}$ tons. The truck is carried on four wheels, and is furnished with two 18-kilowatt Westinghouse motors, coupled to the axles by single-reduction gearing of 1 : 5. The battery consists of 108 cells contained in 12 boxes, which appear to be placed beneath the seats. The capacity amounts to 140 ampere-hours at a discharge of 50 amperes. The time required for charging varies from $\frac{3}{4}$ to 2 hours according to circumstances, the necessary current being supplied by a steam belt-driven Westinghouse dynamo. All active material falling from the positive plates is carefully collected and reapplied from time to time. Up to the present, the running expenses have been low. The coal consumed amounts to 5·1 lbs. per car-mile, and the tractive force is said to vary from about 18 lbs. per ton at starting down to 9 lbs. at a speed of 11 miles per hour on Vignole rails.

W. R. C.

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97. *Power Transmission.* **C. P. Steinmetz.** (Elect. World, 30. pp. 586–588, 1897.)—The author gives a detailed account of the electrical plant for the transmission of power from Mechanicville to Schenectady, a distance of about eighteen miles. The features of interest are:—(1) the generators, which are three-phase alternators of the revolving field type generating direct at 1200 volts, thus obviating the necessity of step-up transformers; and (2) the use of synchronous motors and rotary converters at the receiving end of the line. The synchronous motors are adopted in preference to induction-motors, on account of the control they give over the power-factor of the plant. W. G. R.

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98. *Zickler's Equal Cost Diagram.* (Elect. Rev. 40. pp. 774–776, 1897.)—The writer gives an account of Zickler's investigation with respect to the relative cost of a private generating plant and a supply from a central station. If

P=capital required for purchase of machinery and accessories,
Z=maximum capacity of plant in hectowatts,
T=number of hours per annum of supply per hectowatt,
p=fixed percentage charge on P for interest, depreciation and repairs, and attendance,
β=expenditure for fuel, cleaning, and lubricating materials per hectowatt-hour,
α=price per hectowatt-hour charged by supply company,

then the two costs will be equal when

$$\frac{p}{100}\mathrm{P}+\beta\mathrm{ZT}=\alpha\mathrm{ZT}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

By examining price-lists of dynamos, steam-engines, etc., Zickler finds that P may be expressed in the form

$$\mathrm{P}=\mathrm{AZ}+\mathrm{B},$$

where A and B are constants. The following values of A and B are given by the writer, P being expressed in shillings :—

	Constant A.	Constant B.
Steam-engines	9·3–17·5	975–2400
Portable engines	32·3–41·9	2500–5200
Gas-engines	28–52·3	950–3500
Dynamos	13	550

Putting $\frac{p}{100(\alpha-\beta)}=\mathrm{C}$, $\mathrm{CB}=\mathrm{C}_1$, and $\mathrm{CA}=\mathrm{C}_2$, equation (1) may be written in the form

$$\mathrm{T}=\frac{\mathrm{C}_1}{\mathrm{Z}}+\mathrm{C}_2,$$

which is the equation of a rectangular hyperbola. If the point corresponding to given values of Z and T falls in the region between the curve and the coordinate axes, a central station supply is cheaper; if it falls outside, a private plant is more economical. A. H.

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99. *Electric and Frictional Brake.* **M. Déri.** (Elektrotechn. Ztschr. No. 29. p. 422, 1897.)—In this brake the retardation and stoppage of electrically-propelled vehicles, or of vehicles on which an electric current is available, is effected electrically by means of eddy-currents so long as the motion is rapid enough, but when the motion becomes slow, by frictional contact. The transition from one to the other takes place automatically, so that the axle of the vehicle can be finally brought to rest.

This apparatus comprises a circular series of electromagnets

fixed, by means of a yoke-plate common to them all, to the frame of the vehicle so that their pole-pieces are concentric with one of the axles, the coils being so wound that the pole-pieces are alternately N and S. The ends of these pole-pieces are so shaped as to lie in a conical surface, and are adapted to engage with an armature which is made in the form of a hollow cone of similar pitch to the conical pole-pieces, and is capable of sliding longitudinally through a limited distance on the shaft, but is constrained to rotate therewith by means of slots and feathers. The said armature is also provided with brackets in which are pivoted curved arms arranged to move in a plane passing through the axis of the shaft, and having balls or weights at their outer ends. The inner ends of these arms are forked and adapted to engage with a loosely-fitting collar or sleeve on the shaft, this collar being pressed away from the electromagnets by a spring, and the pivoted arms above-mentioned being so curved that the centrifugal force, due to the rotation of the balls, will cause the inner ends of the arms to press the collar against the spring and so force the armature away from the pole-pieces. The various forces are so adjusted that the magnetic force can overcome the force of the spring alone, but not the combined action of the spring and the centrifugal force of the weights, when the vehicle is running at its normal velocity.

As long as there is no current in the magnet-coils, the armature is held away from the pole-pieces of the magnets. When the magnets are energised, during motion of the vehicle, the armature and pole-pieces are, at first, not brought into contact with each other, but eddy-currents are induced in the armature, which currents produce a powerful retarding force. When the speed has been reduced by these means to a certain degree, the centrifugal force caused by the rotation of the balls is insufficient to hold the armature and pole-pieces apart against the tractive force of the electromagnets, and frictional contact between these parts takes place, which speedily brings the vehicle to a standstill. In this manner wear is reduced to a minimum. C. K. F.

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100. *Small Lighting Plants.* **F. C. Reeve.** (Elect. World, 30. pp. 672–673, 1897.)—This paper deals with the advantages and disadvantages of private electrical plants over purchasing power from Supply Companies. As regards cost and economy the author concludes that private plants have the advantage by amounts varying from 13 to 36 per cent. on the cost per candle-power hour for plants supplying from 25 to 100 lamps of 16-candle power, and concludes that the tendency will be that manufacturers and owners of large shops will produce their own electricity, whilst the sphere of Supply Companies will be to cater chiefly for private houses.

The following table of comparison is of interest, since it gives details of plants in actual operation :—

Table of Costs of Operating Plants.

Max. capacity of plant in 16-c.p. lamps		25	50	75	100
Average first cost of plant		$400	$650	$900	$1100
Interest and depreciation, at 15 per cent.		60	97·5	135	165
Cost of gas and lubricating-oil per lamp-hour		0·30	0·26	0·25	0·24
Cost of gasoline and lubricating-oil per lamp-hour		0·16	0·14	0·13	0·12
Cost per lamp-hour of running with full load 300 hours per year	Gas	1·01	0·91	0·81	0·70
	Gasoline	0·96	0·79	0·70	0·67
Saving, per cent.		13	13	14	15
Cost per lamp-hour of running with full load 600 hours per year	Gas	0·70	0·59	0·53	0·42
	Gasoline	0·56	0·47	0·42	0·40
Saving, per cent.		20	20	21	23
Cost per lamp-hour of running with full load 1200 hours per year	Gas	0·50	0·42	0·39	0·38
	Gasoline	0·36	0·30	0·27	0·26
Saving, per cent.		28	29	33	33
Cost per lamp-hour of running with full load 1800 hours per year	Gas	0·43	0·37	0·34	0·33
	Gasoline	0·29	0·25	0·23	0·21
Saving, per cent.		33	33	33	36

W. G. R.

TELEGRAPHY AND TELEPHONY.

101. *Localising Faults.* **J. Rymer-Jones.** (Elect. Rev. 40. pp. 4–6, 1897.)—The method considered by the author refers to the determination of the position of a partial earth or complete break by tests from one end only. Kingsford and Kennelly have given methods for this case. When using testing-currents of ratios 4 : 2 : 1, Cann noticed that an even closer approximation to the actual position of a break than by using the Kennelly formula may be obtained by the aid of the formula :—

$$\text{Distance of fault} = A + B - C \text{ units,}$$

where A = measured resistance with the strongest current,
B = „ „ intermediate „
C = „ „ weakest „

The author finds, as the result of numerous tests, that

$$B - A = \cdot 5576\,(C - B),$$

and that this relation holds both for widely different currents and also for large and very small exposures. Hence Cann's formula reduces to

$$\text{Distance of fault} = 2\cdot 5576\,B - 1\cdot 5576\,C,$$

and only two measurements, B and C, to instrument zero, need be taken. The author discusses the best conditions for the test, and recommends 10 and 5 milliamperes as the most suitable testing-currents. When the exposure is very small, the calculated resistance to the fault is somewhat higher than its true value, which it may exceed by about 30 units in extreme cases. A. H.

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102. *Telegraphy.* **A. Hess.** (Écl. Électr. 13. pp. 385–390 & 455–458, 1897.)—In these two articles the author gives an account of the so-called "Marconi" system of telegraphy, the chemical system of Delany, and the synchronograph of Crehore and Squier. The articles contain nothing that is new, but the references may be useful. R. A.

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103. *Type-printing Telegraph.* (Electn. 40. pp. 50–51, 1897.)—A type-printing telegraphic receiver, called a "telescriptor," the invention of Bernard Hoffmann, of Austria, is described. In appearance the instrument somewhat resembles a type-writing machine. Each key on the key-board is associated with a corresponding bar of a commutator. On the same axle as the commutator is the type-wheel, arranged so that each bar corresponds to a letter or to a figure. This axle also carries ratchet-wheels for controlling and synchronising the type-wheel. If an earth-return is used, only one line-wire is necessary. The line-current is unidirectional, and the same instrument is available for sending or for

receiving. One pole of the line-battery is connected to earth ; the other is connected to the key-board, and thence to one or other of the bars of the commutator. From the commutator-brush, connection is then made through the coil of a relay to line. The local circuit of the relay controls the clockwork that drives the type-wheel ; it also actuates an electromagnet for approaching or withdrawing the slip to and from the type-wheel. The instrument is very simple, but its working speed is small ; it would seem to have a place between the Hughes' printer and the Wheatstone's A.B.C. apparatus. R. A.

104. *Applications of the Coherer.* **A. C. Brown.** (Electn. 40. pp. 91–93, 1897.)—The author gives a prospective view of the probable applications of the coherer principle. The practical uses may be summarised as :—(1) Wireless telegraphy over moderate distances; ship signalling, military telegraphy, fire alarms, and police calls. (2) The cases where a broken circuit or any short distance requires to be bridged without direct connection, *e. g.* where a wire runs for the greater part of the distance : these cases include railway-signalling, communication to lightships, and working through faulty submarine cables. (3) Relay circuits for land-lines and for submarine telegraphs. (4) Telegraphing over great lengths of bare submerged wires, uninsulated submarine cables, or sheathing wires. The limitations of the use of the coherer are carefully discussed ; signalling over great distances is considered impracticable ; so also is "syntony," except for laboratory purposes. Reports as to the possibility of signalling into iron boxes are discounted. A system of selective receivers is described, whereby each receiver in any municipality may be arranged to respond to a particular set of rated signals, depending upon mechanical harmonic vibration. The most promising application seems to be the use of the coherer in connection with bare submarine cables ; the author indicates that several thousands of miles might thus be traversed. R. A.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

FEBRUARY 1898.

GENERAL PHYSICS.

105. *Atomic Hypothesis.* **L. Boltzmann.** (Annal. Phys. Chem. 61. 4. pp. 790–793, 1897.)—This is a reply to Volkmann's arguments concerning the respective value of the atomistic conceptions and differential equations. Boltzmann maintains that the foundations of the latter method are themselves atomistic, inasmuch as the division of space into space elements, however much reduced in size, involves the idea of discrete entities. An infinite subdivision is mathematically valueless. He illustrates his arguments by reference to Fourier's theory of thermal conduction. E. E. F.

106. *Viscosity in an Electric Field.* **G. Quincke.** (Annal. Phys. Chem. 62 1. pp. 1–13, 1897.)—The author has succeeded in demonstrating an increase of viscosity experienced by dielectric liquids in an electric field. Spheres of crown and flint glass, quartz, and calcspar, 1 cm. in diameter, were suspended by thin silk fibres attached to the arm of a balance. They were immersed in a small trough containing ether, carbon bisulphide, turpentine, benzol, or various mixtures, and surrounded on two sides by condenser-plates 5 cm. square. The logarithmic decrement of the balance was observed with and without a field due to 2000 volts. The difference was the electric viscosity normal to the lines of force. This viscosity was 0·0398 in the case of a crown glass sphere in ether, being the difference between 0·0210 and 0·0608. The mean value for CS_2 was 0·0309, and for benzol 0·0256. Parallel to the lines of force the viscosity also increases, but to a much slighter extent. In both cases the electric damping is nearly proportional to the difference of potential and the dielectric constant of the liquid. E. E. F.

107. *Action at a Distance.* **P. Drude.** (Annal. Phys. Chem. 62. 1. pp. 1–49, 1897.)—The author attempts a strict definition of action at a distance, and discusses the reduction of such action to contact-actions and *vice versa.* He compares the properties of electromagnetic and of gravitational effects and investigates the numerical and formal validity of Newton's law. Finally, he summarises the explanations of gravitational attraction hitherto attempted under the two heads of pressure and impact theories. As regards definitions, if the action is purely mechanical, the condition of distance action is that the energy of a system of material bodies depends not only upon their velocities, but also upon their mutual position; or that relative-position quantities between distinct points of space enter into the energy formula. If electromagnetic and radiation effects are to be included, action at a distance must be defined as taking place when the presence or change of state of a body A produces a change of state in another body B, which would not take place if A were absent or underwent no change of state. Contact-action may take place either through elastic solids or by impact, or by transmission through a compressible or incompressible fluid. The phenomena of electricity and magnetism have been reduced to events in the luminiferous ether, but gravitation remains as an unexplained distance action, chiefly owing to the fact that no propagation of gravitational energy in time has yet been proved. Such a proof is rendered very difficult by the circumstance that gravitational attraction cannot be stopped or brought into play at will. Laplace calculated a minimum value for the rate of propagation from the "aberration" due to the motion of the moon, resulting in a velocity 10 million times that of light. Such an aberration would suffice to explain the irregularities in the motion of Mercury and in Encke's and Winnecke's comets. The same object would be gained by altering the inverse square index from 2 to 2·00000016. The impact theories after Le Sage are so far the only half-way satisfactory solutions. According to Preston's modification, no attraction would be exerted beyond the mean free path of the ether molecules, however large the masses of the bodies. E. E. F.

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108. *Influence of Tension on Torsion.* **M. Cantone** and **E. Michelucci.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 191–198, 1897.)—The authors review a paper on "The Influence of Stress or Strain on the Action of Physical Forces," by Tomlinson, and, considering his experiments as not exhaustive, determine to repeat them with such precautions as they deem necessary, so as to find out if an influence of a similar nature to that found by Tomlinson for permanent torsions could be observed in the case of temporary torsions. The apparatus they use for these experiments is the same as that which was used for magnetic experiments on nickel wire, with the difference that the stretching weights, in order to avoid vibrations which might vitiate the results, are obtained by

two vessels placed horizontally, one fixed and the other suspended by the wire, and communicating by a siphon; on causing a difference in level of the water in the fixed vessel by means of a third movable reservoir connected with it by flexible piping, a gradual increase or decrease of weight is produced in the suspended vessel with a minimum of vibrations. The samples consist of wires of annealed iron, nickel, brass, copper, and silver, and of unannealed copper and silver, 35 cm. long by 2 mm. diam.

The conclusion is that no laws can be formulated, as each metal has a behaviour of its own. When a wire subjected to a torsional couple is loaded, in general the angle of twist increases; but the variation, although consistent, is no simple function of the load. Nevertheless, one can say that, in general, with malleable metals the variation is greater than with the less malleable ones. Nickel presents unique characteristics. Its angle of twist diminishes with increase of load, and *vice versa*. Whereas *un*loaded wire generally shortens with increase of torsion, nickel lengthens. These facts are interesting as exhibiting a connection between the magnetic and elastic behaviour of metals.

In conclusion the authors say that "Tomlinson thought he had found in his investigations a variety of effects which, according to our results, are not characteristic of each substance taken separately, but rather depend on the processes of deformation experienced by the substance. Only one substantial irregularity exists, to our mind, among the bodies examined; and that is the anomalous behaviour of nickel above mentioned." A. Gs.

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109. *Photographic Determination of the Altitude of Balloons.* **L. Cailletet.** (Comptes Rendus, 125. pp. 587–589, 1897.)—Following Cailletet's suggestion, Gaumont has constructed a camera which is suspended from the balloon so as always to hang vertically, and which takes a photograph of the earth below. There are two lenses in the prismatic wooden box; the one below for the purpose mentioned, the other for photographing the needle of the barometer. Between the two moves a strip of sensitised celluloid. The screens are removed by clockwork every two minutes, when the earth's surface and the needle are photographed on the two sides of the celluloid. From the focal distance and the measured distances on the negative between two known objects below, the elevation of the balloon at that moment can be derived within 1 in 500. After experiments on the Eiffel Tower, Hermite and Besançon took the camera up on October 25 at noon in their new silk balloon of 1700 cub. metres, presented by Balaschow. The ascent from the Villette gas-works near Paris lasted four hours, an altitude of 2500 metres being reached. In spite of the boisterous weather 26 good negatives, 13×18 cm., were obtained; the needle of the aneroid was well in the centre of the negative. No particulars are given. H. B

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110. *Determination of the Vertical.* **J. Perchot** and **W. Ebert.** (Comptes Rendus, 125. pp. 1009–1012, 1897.)—The usual nadir determination, coincidence between the micrometer-thread and its image reflected from a mercury-bath, is often difficult at Paris owing to oscillations. There is less trouble with a very thin layer of mercury; but errors might arise from capillary effects. Deichmüller has proposed zenith mirrors floating on mercury. This paper describes tests of such a mirror constructed by Gauthier for Loewy. The mirror, silvered underneath, is fixed on a float resting on an annular mercury trough, held by a lever, pivoted in the pillar with a counterweight at the other end. The float is arrested by means of a hook and four notches at quadrantal points. Three adjustment screws had to be added as the mirror did not come back exactly to its original position after making several turns; correct focussing was obtained by means of proper illumination. Details are to be published in the 'Annales de l'Observatoire.' H. B.

LIGHT.

111. *Photographic Photometry.* **H. T. Simon.** (Ast. Phys. Journ. 5. p. 69, 1897.)—The author uses a spectrometer with a quartz-train for ensuring homogeneity and equality of wave-length of the lights to be compared. One half of a photographic plate is exposed to the standard light at the same time that the other half is being exposed to the unknown light. The plate being put in motion, the intensity of the unknown light is gradually reduced by means of rotating sectors. On development, we have one half the plate uniformly tinted and the remaining half uniformly gradated. The point where there is equality in the two densities is read off, and then, by determining to what degree the unknown light has been weakened at this point, its value in terms of the standard is directly obtainable. C. P. B

112. *Arc Spectra.* **A. L. Foley.** (Phys. Rev. 5. pp. 129–151, 1897.)—A continuation and review of the work of Lockyer in 1879 (Proc. Roy. Soc. 18. p. 425), Gouy (Phil. Mag. 3. p. 238, 1879), and Miss C. W. Baldwin (Phys. Rev. 3. pp. 370–448, 1896), on the spectra of the different regions of the electric arc. The three sheaths of colour are described and illustrated, as well as the Rowland grating and photographic arrangements used in the present research. These latter are very ingenious. Four conditions were studied : (1) vertical arc and vertical slit, (2) vertical arc blown out by a horse-shoe magnet, (3) horizontal arc and vertical slit, (4) arc and slit both horizontal. Elaborate tables are given of the lines with and without the presence of different elements. The much disputed spectrum of carbon is specially examined. S. G. R.

113. *Elastic Bodies and Light.* **P. Glan.** (Annal. Phys. Chem. 60. 1. pp. 174–192, and 60. 3. pp. 563–576, 1897.)—Parts 11 and 12 of this paper deal with the equations of elasticity in crystals, and circularly polarised oscillations in crystals, the investigations being of a highly mathematical character. The vibrations discussed in the second paper are found to be connected with double refraction in crystals in accordance with the laws of double refraction of light. G. H. Br.

114. *Maxwell's Constants for Beech-wood.* **D. Mazzotto.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 95–100, 1897.)—In accordance with Maxwell's relation $n = \sqrt{K}$, to the two different values of the principal indices of refraction in wood correspond two different dielectric constants ; and the differences between the two values

of the refractive index in senses perpendicular and parallel to the fibre coincide appreciably with the differences between the corresponding values of $\sqrt{K}$. As the wood becomes dry the two dielectric constants become much smaller, and, in harmony with the above-mentioned relation, the indices of refraction also fall off; the differences between the new values of the refractive index still remain equal to the differences between the respective values of $\sqrt{K}$, but are considerably less than those presented by wood in the natural state. A. D.

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115. *The Faraday and Zeeman Effects.* **H. Becquerel.** (Comptes Rendus, 125. pp. 679–685, 1897.)—An essential difference exists between the phenomenon of magnetic rotatory polarisation discovered by Faraday and the effect discovered by Zeeman, which latter consists in a change of the period of a luminous source placed in a magnetic field ; no such modification having been observed in the case of the phenomenon of Faraday. Magnetic rotatory polarisation corresponds to a variation in the velocity of propagation of circularly-polarised light. In 1885 the author calculated the velocity of rotation of a vortex motion of the ether, to which the observed phenomena could be attributed; and there is an interesting agreement between the number then indicated and that which can be deduced from the experiment of Zeeman. The author examines the hypothesis which attributes to the ether in a magnetic field equal to unity (C.G.S.) a vortex motion of period θ, and investigates the consequences of this hypothesis in the case of the phenomenon of Zeeman and of magnetic rotatory polarisation.

1. *Zeeman's phenomenon.*—Zeeman has observed that when the spectrum of a sodium-flame placed between the poles of an electromagnet is examined, each of the rays D_1 and D_2 is transformed into a triplet when viewed in a direction perpendicular to the lines of force of the magnetic field, and into a doublet when the flame is looked at in a direction parallel to the lines of force. Considering the last case only: the two components of the doublet are circularly polarised in contrary directions. Moreover, experiment proves that the circular motion whose period is the shorter has the same direction as the current of a solenoid equivalent to the magnetic field. If a magnetic field be considered as a space animated with vortex motions whose axes are parallel to the lines of force, it is possible to examine the consequences of the hypothesis which supposes that this motion is added to the circular motions of one of the two beams into which a beam of natural light can be decomposed, and that it is subtracted from the motions of the other.

Let θ be the period of the vortex motion of the field, N the number of rotations per second of the luminous circular motion outside the magnetic field, the number of rotations will become $N'=N+\frac{1}{\theta}$ for the luminous circular motion of the same sense as the vortices, and $N''=N-\frac{1}{\theta}$ for the inverse motion. The wave

lengths λ' and λ'' of the two circular beams will be different, and denoting by V_0 the velocity of light *in vacuo*,

$$N\lambda = V_0, \text{ and } \frac{dN}{N} + \frac{d\lambda}{\lambda} = 0,$$

hence

$$-\frac{\Delta\lambda}{\lambda} = \frac{N' - N''}{N} = \frac{2\lambda}{V_0\theta}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The variation of wave-length $\Delta\lambda$ should be proportional to the square of the wave-length.

Zeeman has found by experiment $\frac{\Delta\lambda}{\lambda} = \frac{1}{40000}$ for the ray D_1 and a magnetic field equal to 10^4 (C.G.S.); hence for this field $\frac{1}{\theta_1} = 6{\cdot}36 \times 10^9$. If it is supposed that the rapidity of the vortex motion increases proportionally to the intensity of the field, then, for a magnetic field equal to unity C.G.S.,

$$\frac{1}{\theta} = 6{\cdot}36 \times 10^5 \text{ rotations per second.}$$

It is very remarkable that the phenomenon of magnetic rotatory polarisation leads to the same numerical value.

2. *Faraday's phenomenon.*—Fresnel's theory of ordinary rotatory polarisation may be applied to magnetic rotatory polarisation, and the rotation of the plane of polarisation may be considered as due to the different retardations, in crossing a substance placed in a magnetic field, undergone by the two inverse circular rays whose superposition is equivalent to a wave rectilinearly polarised. Let ω be the rotation of the plane of polarisation, e the thickness of the body traversed, V′ and V″ the velocities of propagation of the two circular rays, and T their common period, then

$$\frac{\omega}{\pi e} = \frac{1}{T}\left(\frac{1}{V'} - \frac{1}{V''}\right) = \frac{n' - n''}{\lambda}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The rotation takes place in the direction of the motion of the circular ray which has the greater velocity of propagation.

According to an hypothesis of the author, a circular vibration rotating in the same sense as the medium will behave as if its wave-length was increased: it will then be propagated more rapidly, and the plane of polarisation of a polarised beam will rotate in the sense of the vortex motion of the magnetic field. This view is supported by the results of experiment in the case of the two phenomena considered. The numerical agreement is also satisfactory. Let θ be the period of the vortex motion of the field, N the number of vibrations per second common to two rays circularly polarised in inverse senses. According to the hypothesis, these two rays will behave as if their numbers of vibrations were $N' = N - \frac{1}{\theta}$ and $N'' = N + \frac{1}{\theta}$; to these numbers N′ and N″ correspond wave-lengths

λ' and λ'' and indices of refraction n' and n''. The dispersion-formula of the medium considered gives

$$n'=n+(\lambda'-\lambda)\left(\frac{dn}{d\lambda}\right),\quad n''=n+(\lambda''-\lambda)\left(\frac{dn}{d\lambda}\right),$$

besides

$$\frac{\lambda'-\lambda''}{\lambda}=\frac{N''-N'}{N}=\frac{2\lambda}{V_0\theta},\text{ and }\frac{n'-n''}{\lambda}=\frac{\lambda'-\lambda''}{\lambda}\left(\frac{dn}{d\lambda}\right)=\frac{2}{V_0\theta}\lambda\left(\frac{dn}{d\lambda}\right).$$

Substituting this value in formula (2) it becomes

$$\frac{\omega}{2\pi e}=\frac{1}{V_0\theta}\lambda\left(\frac{dn}{d\lambda}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

In order to approach the conditions of Zeeman's experiment, let $\frac{\omega}{2\pi e}$ be calculated for air. The author formerly found for the magnetic rotation $\frac{\omega}{e}$ of bisulphide of carbon in unit magnetic field (C.G.S.) the number 0·0434 relative to the ray D, and on the other hand he had obtained for the magnetic rotatory power of air, referred to bisulphide of carbon and the ray D, the number 0·000159. Taking $V_0=3\times10^{10}$, then $\frac{\omega}{2\pi e}V_0=9{\cdot}586$. Mascart's experiments on the dispersion of gases lead, for air, to the value $\lambda\frac{dn}{d\lambda}=1{\cdot}443\times10^{-5}$ for the ray D. On putting these values into formula (3),

$$\frac{1}{\theta}=6{\cdot}64\times10^5,$$

a number very near that to which Zeeman's phenomenon leads.

Thus the hypothesis of a vortex motion of the ether in a magnetic field does not appear to be contrary to experiment, and connects together phenomena which are both of them manifestations of the action of a magnetic field on the luminiferous ether. In the case of Zeeman's phenomenon new determinations are necessary to verify if the variation of wave-length is, as the hypothesis indicates, proportional to the square of the wave-length and to the intensity of the magnetic field. J. J. S.

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116. *Zeeman Effect.* **A. Cotton.** (Comptes Rendus, 125. pp. 865–867, 1897.)—The change of the vibratory period of sodium light discovered by Zeeman can be proved very easily by a simple method which does not require any dispersive apparatus. Sodium flames are enveloped by a hot but non-luminous sheath containing sodium. If a flame A be observed when it is placed in front of another B, suitably chosen, the gaseous envelope being absorbent, the edges of the flame A appear black. For example, the flame of a spirit-lamp containing sodium may be taken for A,

and the flame of a Bunsen burner containing a salt of sodium for B. The exterior envelope of the flame absorbs the radiations of sodium light, but it presents in this region of the spectrum only two very narrow absorption-bands. This property is due to the low density of the sodium vapour, and to the value of the temperature in that part of the flame. These absorption-bands are sufficiently narrow to allow the very feeble change of vibratory period of the flame B produced by the magnetic field to suppress the absorption, and to cause the disappearance of the black border of the flame A. By suitable arrangements of the flames with regard to the poles of an electromagnet, observations may be made in directions parallel and perpendicular to the lines of force. J. J. S.

117. *Zeeman Effect.* **A. Cornu.** (Écl. Électr. 14. pp. 185–190, 1898.)—Observations with improved apparatus of high dispersive power show that the central line of the Zeeman triplet is really double; the clearness of definition excluding the hypothesis of reversal. It is inferred that the component vibration parallel to the lines of force is doubled, the periods of the two parts being respectively increased and diminished by the same amount, this amount being proportional to the intensity of the field. Micrometric measurements lead to the conclusion that the effect of the field in producing changes of period depends not only on the chemical nature of the source of light, but also on the nature of the group of spectral lines to which each particular radiation belongs, and the part which it plays in this group. Thus the magnesium group *b* and the zinc group of three blue rays show a rapid increase of the magnetic doubling effect with increase of refrangibility, although the change of wave-length is insignificant. The ray most easily reversible shows the least amount of separation in the doublet. Similarly, the sodium lines D_1 and D_2 give strikingly different effects. To avoid astigmatism, a plane Rowland's grating is used; and the arrangement is such that the micrometer eyepiece is simultaneously in adjustment for all the rays of the spectrum. G. B. M.

118. *Persistence of Period in the Faraday Effect.* **A. Broca.** (Journ. de Physique, 6. pp. 678–681, 1897.)—Experiments made (1) with Thoulet's liquid and a Rowland grating, (2) with transparent iron electrolytically deposited on platinised glass, show no alteration of period. If any part of the rotation is due to change of period, it must be less than 1/4000 of the total effect. G. B. M.

119. *Mechanism of the Rotatory Polarisation of Light in a Magnetic Field.* **A. Broca.** (Comptes Rendus, 125. pp. 696–699, 1897.)—The author describes certain experiments which he made in order to prove rigorously that no change of period takes place as a ray of light traverses the magnetic field. It appeared from

Cornu's investigations concerning the Zeeman phenomenon, that for the production of that effect it is necessary that the source of light should itself be in the magnetised field. Experiments made to discover whether an effect of the same order would be produced by the mere transmission of the ray gave a negative result. This had been previously proved by Tait. These experiments were based on Maxwell's conception of rotatory polarisation, according to which there is no modification of energy as the ray passes. It remains to see whether this would be the case if there be a modification. A change of period would take place by the advance or retardation of a molecule of ether in the trajectory. His experiments disclose no change of period. Experiments made by Cotton and Righi had shown before that there is no absorption nor increase of energy in the magnetic field, with the exception, perhaps, of the case of iron. M. Broca's results show that even in that case, if there be absorption, it takes place without change of period. S. H. B.

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120. *Transmission of Energy and Rotatory Polarisation.* **A. Broca.** (Comptes Rendus, 125. pp. 765-767, 1897.)—In this paper M. Broca proposes to find the characteristic of those parts of a medium where the forces to which the transmission of energy is due have a potential, and those parts where they have not. He proves three theorems.

Theorem I. Let ρ be the quantity of energy per unit of volume, E the flux of energy, $\lambda\ \mu\ \nu$ its components, A the quantity transformed per unit of volume. Then, *Theorem* I.: In the permanent state the vector E is irreversible or reversible, according as there is or is not transformation at the point considered. For simple hydrodynamical considerations give

$$\frac{d\rho}{dt}+\left(\frac{d\lambda}{dx}+\frac{d\mu}{dy}+\frac{d\nu}{dz}\right)+\mathrm{A}=0.$$

If the flux is reversible, the second member may have its sign changed. But if $\frac{d\rho}{dt}=0$, which is the permanent state, this requires that $\mathrm{A}=0$.

Theorem II. The sufficient and necessary condition that a force shall be derived from a potential is that the axes of the ellipsoid of variation of the force coincide with the corresponding directions. In other words, there is symmetric equality.

Theorem III. The sufficient and necessary condition that a force shall not be derived from a potential is that there be transformation of energy at the point considered.

The above considerations show, he says, *à priori* that the rotatory polarisation cannot arise from Zeeman's phenomenon except in absorbent media. The magnetic field itself is a reversible phenomenon, and so, in the absence of absorption, is the ray of light. But if the medium be absorbent, we should expect to find,

if circularly-polarised light and the magnetic field are the same in kind, absence of symmetric equality and transformation of energy. He explains why this had not been observed by Cotton as due to the feebleness of the effect in his experiments. And with regard to the Zeeman phenomenon itself, he points out that we cannot make a circuit in one direction without one in the opposite direction in its neighbourhood, which, if the two are of equal intensity, reduce the magnetic field to one of simple orientation. The magnetic field in the flame may be derived from a potential. But owing to the fact that transformation of energy is going on in the flame, this cannot be concluded with certainty. S. H. B.

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121. *Rapid Exposures in Radiography.* **G. Séguy.** (Comptes Rendus, 125. p. 602, 1897.)—Coat a thin glass plate with bromide emulsion on both sides. Make two flexible screens of linen with Becquerel's violet sulphide of calcium suspended in celluloid. Put one of these screens on each side of the coated glass plate, and back both with black card. Put in a frame under pressure. This gives the thorax very clearly in 30 seconds, and other exposures may even be instantaneous. A. D.

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122. *New Bianodic Bulb with Red Phosphorescence.* **G. Séguy** and **E. Gundelag.** (Comptes Rendus, 125. pp. 602–603, 1897.)—By incorporating with colourless transparent and non-fluorescent glass some albumen in powder and some carbonate of lime or, better, chloride of didymium, a bulb is made which gives, not green, but red fluorescence, which emits twice the Röntgen radiation, and which excites in the screen a brighter fluorescence of a yellowish-green mixed with red. A. D.

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123. *Röntgen Rays and Cutaneous Evaporation.* **L. Lecercle.** (Comptes Rendus, 125. pp. 613–614, 1897.)—Röntgen rays inhibit cutaneous evaporation in the hind quarters of a rabbit. This may go on to complete suppression, and the effect lasts for a long time. In the palm of the human hand the effect is similar, but is smaller and transitory. A. D.

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124. *Dissemination of Röntgen Rays.* **A. Buguet.** (Comptes Rendus, 125. pp. 702–703, 1897.)—Backing the photographic plate with lead makes the details of opaque objects very much clearer. The explanation is that the lead prevents the return of radiations which fog the plate. Protecting the sides of the opaque object by a lead cylinder also hinders radiations scattered through the air from depreciating the sharpness of the margins of the silhouettes obtained. Examples are shown of radiographs of a watch and of a Lebel gun without and with these protections. The time of exposure is materially shortened. A. D.

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125. *Entoscope for Röntgen Experiments.* **E. Ducretet.** (Paris. Soc. Franç. Phys., Bull. 103. p. 3, 1897.)—A short account is given of a Rhmukorff coil, with a mercury interrupter. The author finds that interrupters with solid platinum contacts are inferior to mercury interrupters for Röntgen work. Mention is also made of the entoscope, an instrument proposed by Ducretet in April 1896, and simultaneously by Edison. It is a dark box with holes for the eyes, containing at the other end a fluorescent screen for receiving Röntgen rays. Its object at first was to facilitate Röntgen work in daylight. R. A.

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126. *Propagation of Röntgen Rays.* **G. Sagnac.** (Écl. Élect. 13. pp. 531–539, 1897.)—As yet, the hypothesis that Röntgen rays are ultra-violet radiations meets all the facts. Taking a fairly broad slit as a source, then bringing rays through a fairly fine slit parallel to this, camera-obscura fashion, and then through a fine platinum-wire gauze, and on to a photographic plate: with light, the image of the object is broadened (diffraction); but with Röntgen rays it is not appreciably so, or at any rate not more than would correspond to a wave-length $\frac{1}{14}$ that of light, taking line D or say 0·01 μ. Gouy's work with focus-tubes as sources brings this down to below 0·005 μ. This applies to the particular tubes used, and to transmission through 5 m. of air and through wood. But the absorption by air is extreme: $\frac{1}{10}$ mm. of air extinguishes ultra-violet rays of wave-length 0·1 μ (Schumann); and it may be that the air absorbs those components of the Röntgen radiations which might have shown diffraction phenomena. The scattering of Röntgen rays by air through which they pass is a phenomenon of a different order, analogous to fluorescence or to the scattering of light by tobacco-smoke, much more probably the former. Apparent phenomena of diffraction, observed by several, are really penumbra effects. Mr. Wind has suggested a secondary diffraction; but this, when tested numerically, gives a result much smaller than that observed with Röntgen rays; and the apparent diffraction can be explained as due to phenomena of photographic reversal. The author finds, when precautions are taken to avoid accidental differences, no trace of polarisation by absorption, dependent on the orientation of the absorbing medium; neither has he succeeded in obtaining phenomena analogous to circular dichroism. This does not prove the vibrations not to be transverse: it shows that matter and the vibrations do not react in that way. The absence of refraction is apparently complete, slight indications of it being due to want of parallelism of the slits, and disappearing when this is exact. At any rate, the index of refraction differs, for many substances, by less than 0·000001 (Gouy), and even a difference of 0·0002 would make the Röntgen rays have a wave-length $\frac{1}{600}$ that of line D. These small wave-lengths would explain the absence of refraction and of diffraction (Raveau, L'Écl. Élect. t. 6. p. 249). The apparent deviation of

Röntgen rays near conductors is explicable as an exaggerated penumbra effect: the apparent bending behind opaque bodies is explicable as due to the diameter of the source or to the scattering of the rays by air; and Lafay's "magnetic deviation of electrified Röntgen rays" as due to displacements of the kathode rays in an electric or magnetic field, the results alleged being also denied by Profs. Lodge and Silvanus Thompson. Prof. Stokes has shown the alleged deviation of Röntgen rays by the magnet to be a misinterpretation. No effect of Röntgen rays upon the transmission of light in a vacuum has ever been shown. The only positive fact bearing upon the nature of Röntgen rays, in their propagation, is the ease with which they are scattered by diverse media; and future enquiry will have to be in this direction, since ordinary optical tests are impossible on account of the smallness of the wave-length. A. D.

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127. *Heating Effects of Röntgen Rays.* **E. Dorn.** (Annal. Phys. Chem. 63. pp. 160–176, 1897.)—That the X-rays exert a definite heating effect was already assumed by their discoverer. The effect may be definitely proved by exposing suitable metallic sheets to the radiation in a vessel communicating with a Toepler pressure-gauge, which shows an increase of pressure due to the heating of the sheets and expansion of the gas. That this expansion is not due to dissociation may be proved by reference to the amount of electricity disengaged, according to which the fraction of dissociated air in the bulk of the gas is of the order 10^{-12}, *i. e.* quite inappreciable. Besides, the same increase of pressure may be brought about by the artificial heating of the same metallic sheets, which also enables the observer to accurately determine the amount of the heating effect. The author carried out a series of experiments on this principle, using platinum or palladium sheets mounted at intervals along a cylindrical vessel connected with the pressure-gauge. With 9 accumulators and a sparking-distance of 83 mm., the heat radiated per second was 1·68 mgr.-calories—a very small value in comparison with kathode rays. That the heat was not produced by induced currents in the sheets was proved by interposing a glass plate, which, by absorbing the X-rays, reduced the heating to $\frac{1}{4}$ of its value. E. E. F.

HEAT.

128. *Critical Temperatures and Pressures.* **A. Leduc** and **P. Sacerdote.** (Comptes Rendus, 125. pp. 397–398, 1897.)—The authors find :—For HCl, 52° and 83 atm. (51° and 96, Vincent & Chappuis; 52°·3 and 86, Dewar); for PH_3, 52°·8 and 64 atm.; for H_2S, 100° and 90 atm. (100° and 88·7, Olszewski; 100°·2 and 92, Dewar). A. D.

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129. *Specific Heat of Gases. Fourth Memoir: Part I.* **S. Lussana.** (N. Cimento, 4. 6. pp. 81–93, 1897.)—The author advances the view, based upon experimental evidence described in this paper, that the specific heat of atmospheric air at constant pressure, referred to the unit of mass, depends even for low pressures on the density. This is certainly the case for other gases as well; for carbonic anhydride the coefficient of variation with the pressure, determined by the author, is fully confirmed by the researches of Amagat. This result differs from Regnault's well-known law, according to which the specific heat of atmospheric air per unit mass is independent of the density; and the author carefully points out the points of difference between his experiments and those of Regnault. G. H. Br.

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130. *Superfusion and Freezing-Points of Solutions.* **F. M. Raoult.** (Comptes Rendus, 125. pp. 751–755, 1897.)—The true depression of freezing-point C of a solution, and the depression C′, observed with a superfusion S, are related by the expression

$$C = C'(1-KS),$$

where K depends on the apparatus and mode of observation. The author's previous experiments (Phys. Soc. Abstracts, No. 309, June 1897) gave variable values for K. The present observations, however, made by the same method, show that K is practically constant, its mean value differing little from that calculated by means of an expression formerly given by the author (Revue Scientifique, 1886, p. 683), which takes into account the heat evolved by separation of ice and the loss or gain of heat to or from external sources. The inconstant values of K formerly obtained are attributed to some deviation of the actual conditions of experiment from those assumed in the theoretical equation.

The results communicated in the present paper are as follows:—The molecular depression of freezing-point of potassium chloride increases rather rapidly with diminishing concentration of the solutions, tending toward the limit 36·4 at infinite dilution. For cane-sugar the molecular depression decreases somewhat with

decreasing concentration, the limit being 18·72. The author thinks that it is now definitely proved that the limiting values for the two substances examined are in complete accordance with the theory of Arrhenius. T. E.

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131. *Second Differential Coefficients of Gibbs' Function Zeta.* **W. L. Miller.** (Journ. Phys. Chem. 1. pp. 633-642, 1897.)—In his paper on "Heterogeneous Systems" Prof. Gibbs introduced the function

$$\zeta = e - t\eta + pv,$$

where

$$d\zeta = -\eta dt + vdp + \Sigma\, \mu dm;$$

and the condition that $d\zeta$ should be a perfect differential involves, among others, the relation

$$\frac{\partial\mu_1}{\partial m_2} = \frac{\partial\mu_2}{\partial m_1}.$$

The object of the present paper is to illustrate the importance of this relation for the theory of ternary mixtures, which the author treats under the following heads:—Interpretation of μ; μ as a function of solubility; solubility and electromotive force; freezing-points of ternary mixtures; their vapour-tensions, and their boiling-points. G. H. Br.

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132. *Variation of Energy in Isothermal Transformations.* **H. Pellat.** (Comptes Rendus, 125. pp. 699–702, 1897.)—M. Pellat points out that an error is usually made in calculating the quantity of energy which has to be imparted to a system to maintain its temperature constant. Generally, if T denote temperature, and W external work done, we have two equations of the form

$$dQ = a\,dT + b\,dx,$$

$$dW = h\,dt + k\,dx.$$

If U be energy and S entropy, we have

$$dU = J\,dQ - dW = (Ja - h)\,dT + (Jb - k)\,dx,$$

$$dS = \frac{dQ}{T} \qquad = \frac{a}{T}dT + \frac{b}{T}dx,$$

whence, assuming U and S to be complete differentials, we find

$$b = \frac{T}{J}\left(\frac{dk}{dT} - \frac{dh}{dx}\right).$$

If then dU_T denote the variation of energy of the system in an isothermal transformation,

$$dU_T = (Jb-k)\,dx = \left[T\left(\frac{dk}{dT}-\frac{dh}{dx}\right)-k\right]dx;$$

and not, as usually given,

$$dU_T = -k\,dx.$$

It is usual to neglect b or $T\left(\frac{dk}{dT}-\frac{dh}{dx}\right)$, which, however, is not zero unless dW is a complete differential, which is exceptional. M. Pellat gives an example. A condenser consists of two metal plates; M is the absolute charge on either, V the potential, C the capacity. We have then for the work done, if the absolute charge is increased by dM,

$$-dW = V\,dM = \frac{M}{C}\,dM.$$

And to maintain the temperature constant during this increase of charge, we have to furnish a quantity of heat equal to $b\,dM$.

If with constant charge we increase the temperature by dT, we require a quantity of heat $a\,dT$. In the whole, therefore, if both processes take place the heat required is

$$dQ = a\,dT + b\,dM,$$

while the work done is $-\frac{M}{C}\,dM$.

Comparing this with the general equations, we have

$$x = M, \qquad h = 0, \qquad k = -\frac{M}{C};$$

and therefore

$$dU_T = \left(T\frac{M}{C^2}\frac{dC}{dT}+\frac{M}{C}\right)dM = \frac{1}{C}\left(1+\frac{T}{C}\frac{dC}{dT}\right)M\,dM.$$

Therefore, as the charge increases from zero to M, the heat to be supplied is

$$\Delta U_T = \frac{1}{C}\left(1+\frac{T}{C}\frac{dC}{dT}\right)\frac{M^2}{2}$$

$$= \tfrac{1}{2}MU\left(1+\frac{T}{C}\frac{dC}{dT}\right)$$

(assuming C to be independent of M),

instead of $\frac{1}{2}MV$, as usually given. C varies with the temperature, as it alters the size of the plates. S. H. B.

133. *Thermodynamics of Luminescence.* **K. Wesendonck.** (Annal. Phys. Chem. 62. 4. pp. 706–708, 1897.)—E. Wiedemann has described some cases in which the second law of thermodynamics, precluding the passage of heat from a cold to a hot body, does not apply. A luminescent body, or a flame of 500° made non-luminous by carbonic acid, will further heat a platinum cage which slightly exceeds them in temperature. But these exceptions are only apparent. The conversion of luminous into heat energy has a certain exchange value, and so long as a larger negative exchange value is not proved to exist in the phenomenon of luminescence, the second law cannot be said to be infringed.

E. E. F.

SOUND.

134. *Vibrations of Strings produced by Electric Discharges.* **F. Melde.** (Annal. Phys. Chem. 63. pp. 78–82, 1897.)—The contrivance of bell-ringing by an electric discharge which sets in motion a ball suspended between two bells may be extended to the motion of a metallic string. The string, preferably gold or silver thread, must be insulated at the ends. It is stretched horizontally between the knobs of an influence-machine, or of a battery of Leyden jars. The vibrations are in the natural period, slightly modified by the quantity of electricity passing. By damping at the nodes, the multiple vibrations known to acoustics may be produced. E. E. F.

ELECTRICITY.

135. *Electrodynamical Model.* **A. Garbasso.** (N. Cimento, 4. 6. pp. 260–273, 1897.)—An isolated current without a condenser is represented by rotating a horizontal axis to which are rigidly attached a cross-bar meeting it at right angles and a four-vaned fan. By means of sliding weights acted on by springs the moment of inertia of the system about the axis can be changed, and the vanes of the fans can be turned round the rods to which they are attached, so as to alter the frictional resistance of the air. The analogy of a single conductor with a condenser is obtained by clamping the end of the axis to one end of an elastic wire, stretched horizontally in the same line with the axis and clamped at the other end. The torsional rigidity of the wire corresponds to the capacity of the condenser. The case of two adjacent circuits without a condenser is illustrated by means of two models like that first described, and a connecting mechanism by means of which a rotation communicated to one may be partially transmitted to the other. At one end of the axis of each model is fixed a conical toothed wheel, and these wheels act each on two other similar wheels fitted axially upon a weighted cross-bar. Then, if l_1, l_2 are the moments of inertia of the rotating parts of the models, m that of the intervening mechanism (all with reference to the axis), ω_1, ω_2 the angular velocities of the parts corresponding to l_1 and l_2, the *vis viva* of the whole system is

$$T=\tfrac{1}{2}l_1\omega_1^2+\tfrac{1}{8}m(\omega_1+\omega_2)^2+\tfrac{1}{2}l_2\omega_2^2=\tfrac{1}{2}L_1\omega_1^2+M\omega_1\omega_2+\tfrac{1}{2}L_2\omega_2^2,$$

where $$L_1=l_1+\tfrac{1}{4}m,\quad M=\tfrac{1}{4}m,\quad L_2=l_2+\tfrac{1}{4}m\,;$$

and this is the characteristic form of T for a dicyclic system. Taking account of the frictional resistance, we obtain the equations of motion

$$E_1=\frac{d}{dt}(L_1\omega_1+M\omega_2)+R_1\omega_1,$$

$$E_2=\frac{d}{dt}(M\omega_1+L_2\omega_2)+R_2\omega_2.$$

By using elastic wires, as before, it is possible to illustrate the case of two circuits, one or each of which is connected with a condenser.

G. B. M.

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136. *Poynting's Theorem.* **P. S. Wedell-Wedellsborg.** (Zschr. phys. Chem. 22. pp. 222–224, 1897.)—The object is to prove, with the help of Poynting's Theorem, that Maxwell's equations of the electromagnetic field only hold in free ether, while in the interior of conductors and of molecules they have no meaning. The electric oscillations on a perfect conductor isolated in space

may possibly be unaccompanied by dissipation of radiant energy. This conclusion has an important bearing on Ostwald's theory of the permanence of solar energy. G. H. Br.

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137. *Wimshurst Machines.* **S. M. Keenan.** (Amer. Electn. 9. pp. 316–317, 1897.)—Sectors are not necessary to the working of a Wimshurst machine. When long sparks are required, sectors are somewhat detrimental. Sectorless machines, on the other hand, are not self-exciting, but they can easily be separately excited, and they retain their charge for some time. When the sectors are removed it is necessary to attach several brushes or points to the neutraliser; these and the brushes and points of the collectors should be adjustable. The sectorless machine is said to give a discharge three times greater than a sector machine of similar dimensions, and it will work in all weathers. For Röntgen-ray operations a two-disc sectorless machine is unsuitable; the "current" is said to be too small to excite the Crookes tube. But multiple-plate machines at high speeds answer perfectly for every purpose of experiment and electro-therapeutics with Röntgen-ray apparatus. The writer of the article recommends a 32-inch diameter sectorless machine for this work. The induced charges are made to assume more or less continuous or interrupted oscillation by regulating the sliding discharge-rods. By these, also, the "volume" of the direct discharge may be controlled. They are used in association with a regulated spark-gap in the main circuit of a high-frequency transformer. Such a machine has been in operation with excellent results in the Wayne County Hospital. It produces powerful sparks 15 inches long, described by the author as "absolutely deafening." Nevertheless, patients have been known to recover from its effects. R. A.

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138. *Atmospheric Electricity.* **M. Brillouin.** (Écl. Électr. 13. pp. 577–579, 1897.)—The author seeks to explain the atmospheric electricity by the action of the ultra-violet rays of the sun's light causing the loss of the negative charge produced by induction on needles of ice suspended in the upper strata of the atmosphere when these needles are in an electric field. In support of his theory he has performed some experiments on the loss of electricity of a negatively electrified block of ice, and he finds that so long as the surface of the ice is dry the loss of negative electricity when exposed to ultra-violet light is very rapid. When the surface becomes covered with a film of water, this loss practically stops. The author concludes that the atmospheric electricity is maintained by the action of the ultra-violet rays of the sun on the needles of ice which occur in the cirrus clouds; and that the original charge is produced in the same way, the necessary electrical field to account for the induced charges on the needles being due to the movements of the upper regions of the atmosphere with respect to the magnetised earth. W. W.

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139. *Atmospheric Electricity.* **G. Le Cadet.** (Écl. Électr. 13. pp. 579–581, 1897.)—The author, from the results of the measurements he has made on the strength of the electrical field at different altitudes, concludes that the lower strata of the atmosphere contain electrified masses of air of opposite sign, the positive charged air being on the whole in excess, and that this positive excess, together with the negative charge on the surface of the earth, accounts for the production at a height of about 8000 metres of a field of practically zero strength. To explain the electrification of the air, the author makes use of the effect of ultra-violet light on the particles of dust in the air (*cf.* preceding Abstract). W. W.

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140. *Atmospheric Electricity in the Sahara.* **F. de Courmelles.** (Écl. Électr. 13. p. 583, 1897.)—During the occurrence of the sirocco, the manifestations of atmospheric electricity were found very marked. W. W.

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141. *Dielectric Resistance.* **Bates** and **Barnes.** (Amer. Instit. Elect. Engin. 14. pp. 429–438, 1897.)—In May 1896 a paper was read before the American Institute upon the influence of temperature upon dielectric resistance (see Phys. Soc. Abstracts, No. 769, Nov. 1896). Many of the results seemed fortuitous, and it was suggested that the effect of moisture had perhaps been overlooked. The present paper is a discussion of the earlier one. With regard to the use of cellulose as an insulator, **Perrine** points out that it is an undesirable substance; it begins to decompose at moderate temperatures, even below 100° C. Cotton-covered wire turns brown under like conditions, being aged like the paper of old books. **Steinmetz** regards the phenomena observed by the authors in measuring the resistance of dielectrics at various temperatures as being due, (1) to the change of dielectric resistance, (2) to the effect of moisture, (3) to chemical disintegration. [To these should be added the change in contact-resistance between the dielectric and the electrodes—a most important matter, not referred to by the authors.] He objects to specifications which allow baking before the final test on a paper cable. If the dielectric is fibre of bad quality it will be punctured at low voltage, and still after baking test as of high insulation. Fibre of good quality, after long exposure to damp air, may be of relatively low resistance; but nevertheless it will not be punctured at low voltage. He concludes that specifications for this kind of cable should be drawn up on a basis of spark-resisting power rather than upon a given number of megohms. A fibrous material can be baked to the point of rottenness and still retain very high insulation, but it will have small power to resist a spark. R. A.

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142. *Ambroïne.* **J. A. Montpellier.** (Électricien, 15. pp. 17–19, 1898.)—"Ambroïne" is a new insulating material; it was manufactured in the first instance in Germany, but works have

recently been installed for it in France. Resin, mica, and amianth are part of its composition; these are carefully ground and mixed, and are then submitted to chemical treatment. Finally, the mixture is heated under pressure. The properties claimed for ambroïne are:—(1) That it can be moulded into any form with but small loss of volume, leaving a surface smoother than ebonite under like conditions; this surface is said to be brilliant and polished; working parts of objects moulded in it are said to fit rigorously if the moulds are right. (2) It is claimed to be an excellent insulator; a sheet 0·34 mm. withstands 5000 volts; a rod 1 cm. diam. and 25 mm. long, after 24 hours immersion in water, has 290 megohms, or, after drying, 1000 megohms. (3) It is not affected by light, and is only slightly absorbent of moisture. (4) It resists acids and is not easily affected by heat or boiling water. (5) It is claimed to be about twice as strong mechanically as ebonite; it has also greater resistance to compression. It is made in five qualities for special purposes, *i. e.* one quality that resists the boiling water, a second that holds out against the 5000 volts, a third that withstands the acid, and so on. Particulars as to the quality of the various materials with which ambroïne was compared are omitted; so also are the methods of testing. R. A.

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143. *Frequency Meters.* **M. Aliamet.** (Électricien, 15. pp. 2–3, 1898.)—This is a brief description of two new frequency meters devised by G. Moler and F. Bedell, and exhibited by them at the Detroit meeting of the American Association for the Advancement of Science. The first type involves the use of a very small synchronous motor, and the second of a stretched pianoforte-wire conveying the current and placed between the poles of a powerful magnet, the length of the wire being varied by means of a movable bridge until it is thrown into vibration, and thus made to emit a note. A. H.

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144. *Measurements by Alternating Currents.* **H. A. Rowland.** (Amer. Journ. Sci. 4. pp. 429–448, 1897.)—The author describes a system of measuring capacities and inductions by an electrodynamometer in which the main current (being generally the larger) is led through the fixed coil, and the induced current, or the current through a condenser, is led through the moving coil. These currents then differ in phase, and the resistances in circuit are varied till the phase-difference is 90°, when the deflection is zero. On this principle the author gives six methods for comparing capacity and self-induction, and six for measurement with mutually inductive coils. He describes, further, ten methods of comparing inductions and capacities, using a dynamometer in the ordinary way and balancing to zero-current by varying the resistances. Two methods also are given of determining capacity or self-induction in terms of resistance and frequency, by comparison of the dynamometer deflections. The author has found from experiment that by some of these methods the self-inductions of two coils can

be compared to within 1 in 10,000, and, as capacities, mutual- and self-inductions can be compared one with another, he advocates standards of self-induction for the measurement of all these quantities. He discusses the construction of these and the errors to which they are subject. In measuring resistances by alternating currents, the author claims that accuracy is increased a thousandfold by passing a strong current through the fixed coil of the dynamometer and the testing current through the movable coil.

G. H. BA.

145. *Induced Currents.* **L. Arons.** (Annal. Phys. Chem. 63. pp. 177–182, 1897.)—The author calculates the current, resistance, and E.M.F. for an interruption accomplished in 0·003 second of a circuit containing a coil with an iron core, the original E.M.F. of the steady current being 100 volts. Just before total interruption the voltage exceeds 1 millim. The general theory is given. E. E. F.

146. *Counter-E.M.F. of Aluminium Arc.* **V. von Lang.** (Annal. Phys. Chem. 63. pp. 191–194, 1897.)—The fact that an electrolytic cell of aluminium and an indifferent electrode such as carbon or platinum allows a free passage to a current passing from the carbon to the aluminium, but opposes it in the opposite direction with a counter-E.M.F. of 22 volts, may have some connection with the counter-E.M.F. of an arc between aluminium electrodes. Experiments with such an arc gave a counter-E.M.F. of 18·8. With one carbon electrode the counter-E.M.F. was greater for a current C—Al than for a current Al—C. An arc can therefore also be used for converting an alternating into a continuous current; but the loss is great, only 6 per cent. being so converted.

E. E. F.

147. *Electric Arc.* **G. Claude.** (Électricien, 14. pp. 257–260, 1897.)—This is merely a summary of investigations on the behaviour of the electric arc under varying pressures of the surrounding atmosphere, and a discussion of the observed phenomena. Starting with the assumption that the temperature of the arc corresponds with that of ebullition of carbon, the author argues that increase of pressure in the surrounding atmosphere should cause an increase in the temperature of the arc, and explains the observed diminution in the brilliancy observed by Wilson under a pressure of 20 atmospheres by supposing the atmosphere to become a mixture of air and vapour of carbon at the higher temperature. W. G. R.

148. *Efficiency of Alternating Arc.* **W. B. Burnie.** (Electn. 39. pp. 849–855, 1897.)—It is known that a peaked E.M.F. wave is best for transformers, and a flat one for arcs. The reasons for the higher luminous efficiency of the arc with flat-topped as opposed to peaked waves have hitherto been imperfectly understood. The researches of Blondel, Görges, and Fleming have

shown that the light emitted by an arc follows the rapid fluctuations of the current supplying it. The object of the present research is to ascertain whether the heat-radiation undergoes the same variations as the light-radiation. The apparatus used consists of an arrangement of mirrors, by means of which the direction of the radiation coming from the arc can be varied; a synchronous motor, carrying a slotted disc whose position relatively to the shaft may, by an ingenious device, be varied whilst the motor is running; a fixed slotted disc through which the radiation is transmitted at the instant of coincidence of the two slots; and a Joubert contact-maker for ascertaining the P.D. and current-waves. A Bunsen photometer is used for ascertaining the luminous intensity, and a bolometer made of tinfoil for determining the thermal intensity. Preliminary experiments showed that the direction of greatest luminous intensity was sensibly the same as that of greatest thermal intensity. This direction of greatest intensity was chosen in determining the fluctuations occurring during a period. The results obtained show that, although the thermal intensity fluctuates, the fluctuations are not nearly so great as those of the luminous intensity. *From this it follows that the fluctuations which occur during a period are due to temperature changes in the bright surfaces of the carbons, and not to changes in their areas.* Now the efficiency of the arc will be greater, the greater the ratio of the luminous to the thermal radiation. And since this ratio increases with the temperature, it follows that the highest temperature will also give the highest efficiency. But there is an upper limit to this efficiency—that determined by the temperature of volatilisation of carbon. If a larger current than that required to maintain this temperature be passed through the arc, a large amount of carbon will be volatilised uselessly, and the efficiency will be reduced. The conditions for highest efficiency are stated thus: the arc has in one particular condition the highest possible efficiency, and so the current-value should rise rapidly to a maximum after its passage through zero in order to destroy the effect of the cooling during this time, and to heat up the positive carbon till the desired state is reached. The current should then fall to such a value as will maintain this state, and remain constant for the remainder of the half-period. The best form of current-curve would therefore be one of which each half-wave consists of two parts, each flat-topped, the earlier part having a greater value than the later one. This fully explains why flat-topped waves give better results than peaked ones. A. H.

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149. *Electrical Conductivity Test.* **E. G. Willyoung** and **H. P. Harth.** (Elect. World, 30. pp. 579–581, 1897.)—This is an adaptation of the "Carey-Foster" method to the measurement of the conductivity of short lengths of copper rods or tubes for commercial purposes. The conductor to be tested takes the place of the bridge-wire. The two "fixed" coils and the two "reversible"

coils have known values. By observing two scale-readings, corresponding to the two positions of the "reversible" coils, a certain length of the specimen is determined; the resistance of this length is equal to the difference of resistance of the two "reversible" coils. From the measured dimensions and weight of the specimen conductivity can then be calculated. In exchanging the "reversible" coils there is risk of introducing unequal contact-resistances. To avoid this the "reversible" coils are themselves permanently connected to the bridge; the required resistance-differences are obtained not by exchanging, but by shunting these coils. It is shown that errors introduced by the method of shunting are less than those of the exchanging method. Thermal currents are reduced by making all the bridge-bars of copper. The slide-bridge, together with the specimen rods, are enclosed in a box during testing. For commercial purposes it is important to check the conductivity of the various supplies of copper by a quick test. The author can check about twelve specimens in an hour. In stated examples he gives the conductivity to two decimal places. R. A.

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150. *Electric Conductivity of Pine-wood.* **D. Mazzotto.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 134–141, 1897.)—In air-dried pine the absolute specific conductivity along the fibres was found to be 280×10^{-19} C.G.S. units; and this fell steadily to $0{\cdot}5 \times 10^{-19}$ as the wood was dried in a stove at 100° C. Across the fibres the conductivity ranged, under the same conditions, from 112×10^{-19} down to $0{\cdot}0125 \times 10^{-19}$. It is, however, to be remarked that the values thus found for the conductivities are still a little too small, since the diminution of the index of refraction and of the dielectric constant, which take place on desiccation, and the smaller values which these present perpendicularly to the fibre, modify the apparent value of the conductivity. A. D.

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151. *Law of Electric and Thermal Conductivities.* **F. A. Schulze.** (Annal. Phys. Chem. 63. pp. 23–28, 1897.)—According to Wiedemann and Franz, the ratio between the thermal and electric conductivities is approximately the same for all metals, being about $1{\cdot}6 \times 10^{3}$ for Pb, Zn, Sn, and Cd according to Kirchhoff and Hansemann. The various specimens of iron and steel examined showed different values from these. The author determined the two conductivities for six specimens of iron and manganese steel. The ratio of the thermal to the electric conductivity was $1{\cdot}406 \times 10^{3}$ in the manganese steel specimen, while some of the iron rods go as high as 2·3 or even 7×10^{3}. The ratio does not increase with the coercive force. E. E. F.

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152. *Electrolytic Conductivity by Rapid Oscillations.* **J. A. Erskine.** (Annal. Phys. Chem. 62. pp. 454–459, 1897.)—The resistance of an electrolyte may be determined by observing

the thickness required to produce a given screening action upon electric oscillations. According to J. J. Thomson, the screening action is directly proportional to the conductivity. The author immersed an oscillator, consisting of a ring with two gaps, in an evaporating basin filled with petroleum, and placed another dish with a flat glass bottom on the top. This dish contained a similar receiver, immersed in the electrolyte to be studied. The smaller gap of the resonator contained a coil of wire surrounding a testing-needle acting upon a magnetometer. The observation of the sparks in the resonator was replaced by an observation of the magnetometer deflection as affected by the currents traversing the demagnetising coil. The demagnetising effect produced across any thickness of the electrolyte was compared, by interpolation if necessary, with the demagnetising effect produced across the same thickness of some standard solution, and the ratio thus obtained was the ratio of the resistance. In the following table the resistances thus obtained are compared with those obtained by Kohlrausch for continuous currents.

Substance.	Density of solution.	Resistance.	Resistance for continuous currents.
NaCl	1·035	2·50	2·44
,,	1·109	1·0	1·0
,,	1·19	0·77	0·77
H_2SO_4	1·104	0·30	0·30
HCl	1·049	0·25	0·26
HNO_3	1·035	0·52	0·53
KCl	1·10	0·79	0·81
NH_4Cl	1·042	0·62	0·64
NaOH	1·057	0·81	0·79
K_2CO_3	1·192	0·81	0·85
KNO_3	1·133	0·94	0·92
$NaC_2H_3O_2$	1·051	3·41	3·41

The waves used were 170 cm. long in petroleum. The standard solution in every case was a NaCl solution of density 1·109. The temperature was 18°. The author also tried whether a badly conducting liquid of high dielectric capacity produced any perceptible screening. A layer of water 1·2 cm. thick produced no perceptible screening. E. E. F.

153. *Temperature Coefficients (Electrolytic).* **C. Cattaneo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 89–94, 1897.)—The author found some years ago that the electrical conductivity of ethereal saline solutions diminished at higher temperatures, contrary to the general rule for liquids, but similarly to the rule for metallic conduction. By a series of experiments, which were somewhat complicated through loss of ether by evaporation or by the absorption of water-vapour, it was found that solutions could be made which offered great resistance and in which the conductivity did not vary with

the temperature to any material extent. Such a solution may be made by mixing, say, 75 of alcohol with 100 of ether, both as nearly as possible anhydrous, adding a small trace of ferric chloride; then tentatively vary the temperature and observe the conductivity, adding drops of alcohol or of ether as the case may be, until the conductivity remains the same under variations of temperature; then hermetically seal up this solution. The proportion of ether to alcohol depends on the concentration of the solution. Chlorides of gold, of platinum, of mercury also act in the same way; and with chloride of gold the proportion of alcohol present in the mixture of alcohol and ether is smaller than it must be in the case of ferric chloride. A. D.

154. *Theory of Galvanic Polarisation.* **A. Oberbeck.** (Annal. Phys. Chem. 63. pp. 29–35, 1897.)—F. Streintz has maintained that the determination of the galvanic polarisation in the original circuit is impossible, even when alternating currents are employed. The author shows that this is not proved, and makes the following assumptions:—(1) In the case of feeble polarising forces the electrolytic cell behaves like a condenser, or, rather, like two condensers in series. (2) With stronger forces this assumption is only approximately true, but the capacity is a function of the polarisation, and increases with it. (3) The capacity becomes infinite when a superior limiting value of the polarising force is reached, which coincides with the maximum polarisation. From that point onwards the polarised cell acts like a constant cell in opposition to the primary current. There is another element, viz. the spontaneous depolarisation, or the loss of effectiveness of some of the polarising ions with time; but this process is not yet well understood. Neglecting this process, we have

$$\mathrm{R}i=\mathrm{E}-p$$

under all circumstances. The assumption (1) is complied with by

$$\mathrm{C}\frac{dp}{dt}=i,$$

where C is the constant capacity of the cell. Taking in assumption (2), the right-hand side of the last equation becomes eventually

$$\left(1-\frac{p}{\mathrm{P}}\right)i-kp,$$

where P is the limiting polarising force above mentioned. The polarisation may then be expressed in terms of the current-strength by the formula

$$p=\frac{\mathrm{P}i}{i+k}.$$

As the current increases the polarisation maximum is approached asymptotically. When the polarisation is very feeble, the depolarisation at break consists of a quick current-impulse followed by a prolonged constant residual current. Most of the phenomena can

be described as producing an apparent increase of resistance, which is strongest for the feeble resistances and which vanishes at and above the maximum polarisation. The observations of polarisation hitherto made have not been fruitless. They have led to conceptions concerning its nature which are, on the whole, correct and only require filling out in detail. E. E. F.

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155. *Measurement of Self-Induction.* **M. A.** (Électricien, 14. pp. 299–300, 1897.)—This is a method due to Herr Thiermann, professor of physics at l'École polytechnique, Hanover. The method consists in measuring the steady current flowing round the coil whose self-induction is to be measured by means of an ammeter, and the induced transient current by means of a standardised ballistic galvanometer. The self-induction of the coil is then proportional to the ratio of the induced to the steady current passing through it. The chief feature of the method is the use of a particular type of key, by means of which the circuit remains a closed one when the battery-circuit is open. W. G. R.

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156. *Magnetic Testing Apparatus.* **R. B. Treat** and **J. W. Esterline.** (Elect. World, 30. pp. 696–697, 1897.)—The apparatus described resembles in some respects Ewing's Permeability Bridge, and in others the apparatus used by Ayrton. It consists of two massive yokes of wrought iron, provided with a clamping arrangement for holding two test-bars placed side by side as in Ewing's Bridge. Each bar is surrounded by a coil, and the number of effective turns in one of these coils may be varied by steps of one turn at a time, an equivalent resistance being thrown in as each turn is cut out. The yokes curve back over the test-bars, and are bored out to form two pole-pieces, between which is placed a small armature of the Pacinotti type. The length of test-bar between yokes is 4π cm. The area of air-gap at the joint with yokes is 32 times the area of test-bar; the length of air-gap between armature and pole-pieces is ·01″, and its area is 36 times that of test-bar. The armature is driven at 4000 revs. per min. The specimens, if solid, are in the shape of cylindrical rods 10 inches long and ·575″ dia. Sheet-iron specimens are built up into square rods, the side of the square being ·41″. There are three ways of using the instrument:—(1) One of the two bars is a standard bar, with which the other is compared, the revolving armature indicating any difference of magnetic potential which may exist between the yokes; (2) the hysteresis cycle of a specimen may be determined by removing the standard bar, and deducing **B** from the armature E.M.F.; (3) the **B**–**H** curve may be determined by this latter method if the specimen is demagnetised to start with.
A. H.

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157. *Magnetic Properties of Iron and Steel.* **J. A. Fleming.** (Electn. 39. p. 860 &c., 1897.)—The paper commences with an

account of the fundamental facts of magnetic induction. Permeability, retentivity, coercivity, and hysteretic constant are considered in turn. The effects of temperature-changes on permeability are discussed, and the results obtained by Dr. Morris are exhibited in a series of curves. Generally speaking, for small magnetic forces the permeability is increased by a rise of temperature, while for large forces it is diminished. At a certain critical temperature (which lies between 700° C. and 900° C. for different specimens) the permeability drops very suddenly to a value not far from unity. Retentivity is not influenced by the presence of carbon in the iron, but coercivity depends very largely upon the chemical composition of the specimen. The hysteretic constant diminishes with increase of temperature and vanishes entirely at the critical temperature (if the iron is continuously heated up). Prolonged slow heating at 60° or 90° C. has, however, generally the effect of gradually increasing the hysteretic constant to two or three times its original value. By properly annealing the material, this effect may be to a large extent eliminated; steel may be produced with a non-ageing quality which is superior to that of iron.

The author next propounds a theory to account for the known ferro-magnetic properties of iron. There are many facts (such as the production of non-magnetic steel by the addition of manganese) which appear to point to the conclusion that it is the molecule, and not the atom, which is the magnetic unit. A brief outline of Ewing's molecular theory is given: this theory only accounts for observed facts by transferring the magnetic property of a mass of iron to one of its molecules; it does not attempt a solution of the ultimate cause of magnetic phenomena. The starting-point of the author's theory is that the atoms of all bodies carry on them electrical charges. The ferro-magnetic properties of iron may then be explained by assuming that its molecules consist of electrically-charged atoms arranged in a particular way and that they are in a state of rotation. A four-atom molecule is considered which consists of four electrons, two positive and two negative ones, grouped at the four corners of a square, the electrons at the extremities of a diagonal being of the same sign. If such a molecule be set rotating about a diagonal, the rotating electrons will be equivalent to an electric current: the molecule will, in other words, possess a certain magnetic moment. But an electron revolving in an orbit gives rise to radiation in the ether; and since the frequency of the waves emitted at ordinary temperatures is of the order 3×10^{13}, this may be assumed to represent the number of revolutions per sec. of the molecule. When the molecule is rotating steadily, the centrifugal action due to the masses of the revolving atoms is balanced by the electrostatic attraction. Using the results deduced by Lord Kelvin and others for the probable mass of a molecule of hydrogen, the author finds for the probable mass of an atom of iron $\frac{3}{10^{22}}$ of a gramme. Thus

(making use of the known value of the electrochemical equivalent of iron) the probable charge carried by every atom of ferric or tetrad iron is $\frac{6}{10^9}$ of an *electrostatic* unit. From these data the radius of the orbit, and hence the magnetic moment of the molecule, may be determined. The greatest intensity of magnetisation will be obtained when all the molecules face one way. The intensity will then be equal to the magnetic moment of each molecule multiplied by the number of molecules in a cubic centimetre. This gives a maximum intensity of 1000 C.G.S. units. Since the actual limit is somewhere about 1700, it is seen that the hypothesis is capable of accounting for the limits of magnetisation actually observed. The effect of increasing the temperature is to break up some of the molecules into two-atom groups, which cannot have any magnetic moment. At the critical temperature this molecular decomposition proceeds rapidly: hence the sudden decrease of permeability. There is also other evidence to show that violent molecular disturbances take place at the critical temperature: the specific heat and temperature-coefficient of electrical resistance reach maxima values at this point.

In order to explain the various effects produced by temperature changes and the presence of carbon &c., the author supposes that every ferro-magnetic substance consists of a *matrix* of comparatively simple molecules (four-atom), throughout which ramifies a network or *web* of bonded molecules (consisting of a large number of atoms). The formation of the more complicated molecules constituting the *web* is facilitated by the presence of a polyvalent element, such as carbon, in small proportions. Heat breaks up the network, resolving it into simpler molecules, which will then possess greater freedom of movement. With low magnetising forces only the *matrix* will respond readily; but if heat be applied the *web* is to some extent broken up, and more molecules are free to respond to the magnetising force—*i. e.*, the permeability is increased. With high magnetising forces, on the other hand, even the molecules composing the *web* may be made to turn, so that a breaking-up of it by heat does not produce much effect. Heating to a high temperature breaks up the web, and if the cooling be slow, the web is not fully re-formed: hence the high permeability of annealed iron. The hysteretic *ageing* of iron is due to a gradual re-formation of the web. The presence of carbon, by facilitating the formation of a web, reduces the permeability. A. H.

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158. *Magnetic Properties of Tempered Steels.* (Électricien, 15. pp. 28–29, 1898.)—The article gives an account of some experiments by Mme. Sklodowska-Curie on the magnetic properties of steel from the point of view of their importance in the construction of permanent magnets. Rods and closed rings were studied. The rods were heated in an electric furnace by a spiral of platinum, then dipped in water. The heating current magnetised the rod, the magnetisation of which was followed by means of a deflection-

magnetometer. Mme. S.-C. finds that the rod only hardens if the temperature of the furnace is raised higher than that of recalescence ("température de la transformation magnétique"), that is to say, when the magnetisation is very small at the moment of hardening. The properties of importance are the residual magnetism and the coercive force. Steel (in the absence of other metals) containing 1·2 p. c. of carbon is best adapted for permanent magnets. Metals do not in general appreciably affect the residual magnetism, but many of them increase the coercive force. Nickel, chromium, and copper in small quantities appreciably improve the steel; but tungsten and molybdenum are the most remarkable in their action. The coercive force of ordinary steel may reach or pass 60; it attains values of 70 to 74 for tungsten- and of 80 to 85 for molybdenum-steel. The greater the coercive force the less the effect of shocks. A heating to 200° injures the steel; a heating to 100° is detrimental. It is best to heat the steel to 60°, taking care to partially demagnetise it immediately after having magnetised it to saturation. A. Gs.

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159. *Torsion and Magnetism.* **P. Drude.** (Annal. Phys. Chem. 63. pp. 9–15, 1897.)—The change in magnetic susceptibilities of a body in different directions due to mechanical deformations of an isotropic body depends upon two constants. If δ_1, δ_2, and δ_3 are the chief dilatations, and μ_1, μ_2, μ_3 the magnetic conductivities in the corresponding directions, then

$$\left\{\begin{array}{l}\mu_1=\mu-\mu'(\delta_1+\delta_2+\delta_3)-\mu''\delta_1.\\ \mu_2=\mu-\mu'(\delta_1+\delta_2+\delta_3)-\mu''\delta_2.\\ \mu_3=\mu-\mu'(\delta_1+\delta_2+\delta_3)-\mu''\delta_3.\end{array}\right.$$

When a wire suffers simple stretching, all three dilatations occur in each volume element, and $\delta_1+\delta_2+\delta_3$ is in general different from zero. But this sum is zero in the case of torsion. Hence the relations between torsion and magnetism cannot be explained by a simple stretching of the elements of the twisted wire. The simplest case, and the only one that can at present be dealt with by calculation, is that of a piece of iron freed from magnetism by incandescence, then deformed, and finally subjected to magnetisation. A reversal of the last two operations gives a different result, the currents in an induction-coil having the iron for a core being in the ratio 17·5 : 13·5. If the longitudinal magnetisation of such a twisted wire is supposed to be calculated solely on the basis of magnetic eolotropy, a very convenient and exact means is given for the calculation of μ''. The author obtains the formula

$$\mathrm{N}=-\frac{\pi}{2}\mu''ei\mathrm{R}^2,$$

where N is the number of lines of force traversing the section of the wire, R is its radius, i the current along the wire, and e the torsion per unit length. The value obtained for μ'' is $-400{,}000$, whereas the value found by Cantone was about double that. This may be due to a difference in the specimen. E. E. F.

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160. *Magnetic After-Effect.* **I. Klemenčič.** (Annal. Phys. Chem. 63. pp. 61–65, 1897.)—Viscous magnetic hysteresis, or magnetic after-effect, is best observed in specimens of soft iron and in weak fields. In stronger fields the after-effect increases, but not in the same proportion to the temporary magnetisation; so that it soon vanishes in comparison with the latter. Experiments made with wires of various diameters show that the after-effect increases with the magnetisation and tends to a maximum, which is probably reached long before magnetic saturation. Thus, in varying the field from 0·16 to 1·63, the percentage after-effect decreases from 8·3 to 1·8 in a wire 0·6 cm. thick, and from 10·7 to 1·7 in a wire 0·4 cm. thick. The effect is the same whether the change of field is brought about by closing and opening the magnetising circuit or by reversing it. E. E. F.

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161. *Atomic Magnetism.* **G. Jäger** and **S. Meyer.** (Annal. Phys. Chem. 63. pp. 83–90, 1897.)—The authors investigated the magnetic susceptibilities of water and of solutions of nickel, cobalt, iron, and manganese, by Quincke's manometer method. They found that the acid of the salt exerted no influence, and obtained the important result that the atomic magnetisms of Ni, Co, Fe, and Mn are exactly in the ratios of 2:4:5:6. It is highly probable that chromium fills up the gap between nickel and cobalt with the number 3. The absolute values for $\kappa \times 10^5$ for one gramme-atom are

Nickel	4·95	Iron	12·5
Cobalt	10·0	Manganese	15·0

The temperature-coefficient is about $-0·0025$. The value for water is $-0·652$ at 2°·4 C. E. E. F.

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162. *Dielectrics in a Magnetic Field.* **K. R. Koch.** (Annal. Phys. Chem. 63. pp. 132–136, 1897.)—In view of the theoretical relations between the dielectric constant and the refractive index of a substance, it is interesting to enquire whether either of them is affected by a strong magnetic field. The author describes experiments on the refractive index of various liquids, both paramagnetic and diamagnetic, in various magnetic fields, homogeneous and otherwise, carried out by means of an interference refractometer. No change of refractivity due to magnetisation was observed. E. E. F.

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163. *Magnetic Images.* **H. Jaeger.** (Annal. Phys. Chem. 63. pp. 137–141, 1897.)—The author investigated the field of a straight insulated wire lying on a broad thick plate of iron and traversed by a constant current, by means of an exploring coil and a galvanometer showing 10^{-9} amperes. The axis of the exploring coil was placed in the direction of the magnetic dip, thus eliminating the influence of the earth's magnetic field. It was found that the field

as modified by the iron plate was precisely that which would have been produced by the original wire *plus* another identical wire placed in the position of the reflected image of the former in the plate. The same was the case with a coil. This extends S. P. Thompson's conception of magnetic images to constant currents.

E. E. F.

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164. *Demagnetising Factors.* **M. Ascoli.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 129–134, 1897.)—Experiments confirming previous results, that solid cylinders and bundles of wires have similar distributions of induced magnetism, the only difference being that the cylinders have slightly less permeability; and there is no difference between cylinders and bundles in respect of the demagnetising factors.

A. D.

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165. *Thermo-magnetic Properties of Bismuth.* **R. Defregger.** (Annal. Phys. Chem. 63. pp. 97–102, 1897.)—In repeating the experiments by Ettingshausen and Nernst on the thermo-magnetic transverse and longitudinal effect in bismuth, the author found that their contention as to the independence of the effect from the nature of the electrode wires does not apply to the longitudinal effect. They got rid of the thermo-electric currents altogether by using a peculiar shape for the plate of bismuth in which the warm and cold portions of the plate are brought into the circuit by pieces of the metal itself. The abolition of the thermo-currents annuls the longitudinal effect. It is seen, therefore, that a thermo-magnetic longitudinal effect, corresponding to the thermo-magnetic transverse effect, does not exist, but that the appearance is due simply to a change in the original thermo-electric current. This change is accounted for by the property of bismuth, discovered by Grimaldi, of changing its thermo-E.M.F. in a magnetic field with respect to other metals. The "galvano-magnetic temperature-difference" in a longitudinal direction observed by Nernst, must be interpreted as implying that the amount of Peltier heat at the ends of the bismuth rod changes in a magnetic field, thereby producing a slight change of temperature at these points. The change of resistance of bismuth in a magnetic field cannot be interpreted as a "longitudinal Hall effect."

E. E. F.

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166. *Carbon Coherer.* **F. J. Jervis-Smith.** (Electn. 40. p. 85, 1897.)—If the conditions are right, carbon coherers are extremely sensitive detectors for Hertz waves. To get the best results the carbon should be finely powdered, and the resistance should be such that, initially, a small current flows through the circuit. This last condition is obtained by providing pointed terminals that can be screwed to any required depth into the powdered carbon contained in a tube. Such a sensitive state is scarcely possible with metallic filings. The apparatus, set up in

this way, is a delicate indicator of approaching storms. The author tried to increase the sensitiveness still further by exhausting the containing tube; but a vacuum does not appear to improve matters. R. A.

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167. *Electroscopic Detection of Waves.* **A. Toepler.** (Annal. Phys. Chem. 63. pp. 183–190, 1897.)—Where a highly sensitive coherer cannot be employed, it is possible to demonstrate the existence of electric resonance-waves by a modified electroscopic arrangement. A fine aluminium wire is suspended between two upright cylindrical metallic rods, one of which is put to earth. To give the utmost freedom of suspension, the wire is attached to a steel needle, which in turn is held by a magnet. It oscillates about its point, and the magnet is only just powerful enough to keep it suspended. An image of the wire is thrown on a screen, and secondary sparks of a length of only 0·002 mm. length are indicated by the vibrations of the suspended wire. Resonance has thus been detected at a distance of 21 m. across intervening objects. E. E. F.

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168. *New Indicator of Electric Waves.* **A. Righi.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 245–246, 1897.)—In the course of experiments on the passage of electricity through rarefied gases, it was noticed that when a tube of rarefied air was connected up to a battery of electromotive force not quite sufficient to drive a current through it, very small disturbances, such as the approach of the hand to the tube, caused the current to flow and the tube to become luminous. The author finds that under certain conditions the electric waves generated by the discharge of an electrical machine produce the same result. The passage of the current may be aided or hindered, according to the pressure of air in the tube, the form of the tube, and the position and distance apart of its electrodes. Cessation of the waves causes cessation of the current in some cases, so that a galvanometer or a relay in the circuit of the battery and tube would receive signals transmitted by the electric waves. The instrument has about the same sensitiveness as the coherer, with the advantage that no shaking is necessary after the reception of each wave. As in the case of the coherer, the action of the wave seems to take place, not on the tube itself, but on the conductors connected with it.

The tubes with which the above results were obtained were constructed as follows:—They are very small, spherical or nearly so in shape, and carry two wire electrodes tipped with platinum, each of which is bent at a right angle at its end so as to form the adjacent sides of a rectangle. The point of one electrode is then turned at a right angle against the cylindrical part of the other one, and is separated from it by about a tenth of a millimetre. The pressure of the air in the tube is very nearly that for which the smallest number of cells is required to drive a current through it, and the number of cells used (copper—water—zinc) varied from 300 to 600. J. L. H.

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169. *Period of Oscillation in Lecher Apparatus with Secondary Wire Appendices.* **D. Mazzotto.** (N. Cimento, 4. 6. pp. 172–185, 1897.)—The Lecher apparatus gives a fundamental electromagnetic wave and another, secondary, of much smaller wave-length. The present note is devoted to calculating the period of the fundamental wave.—In the apparatus, two condensers, equal to and parallel with one another, have their nearer plates connected by short wires with metallic balls between which there is a spark-gap. The further plates are connected with two long parallel "secondary" wires. According to Cohn and Heerwagen, the two condensers when the spark passes form a system of two condensers in cascade, equivalent to one of half the capacity of either; and we may assume the two proximal extremities of the secondary wires to be connected with the two plates of such a single condenser of half capacity. If from the end of one secondary wire to that of the other a wire is fixed to serve as a bridge, waves from the spark are reflected on reaching the bridge and form stationary waves along the secondary wires. In that case (Cohn and Heerwagen) the wave-length λ is, when there are no nodes between the condenser and the bridge—and when z is the length of either secondary wire up to the bridge, d the distance between the two parallel secondary wires, R the radius of either, and C the joint capacity of the condenser—

$$\lambda = 8\pi \mathrm{C} \log (d/\mathrm{R}) \,.\, \tan (2\pi z/\lambda).$$

In 1864 Kirchhoff had reached a similar result through considering the actions in the conducting wire. If we connect two equal wires with corresponding points of the secondary wires, these two wires being straight, fixed at right angles to the secondary wires, and having each one end free, the waves bifurcate at the junction, the part which runs along either appended wire being reflected at its extremity; and this applies both to the direct wave and to that reflected from the bridge. Without these additions the problem is comparatively simple: with them, we have to make equations for the current in the secondary wire up to the junction, in the same beyond the junction, and in the appended wire itself, and we then have to eliminate arbitrary constants with the aid of limiting cases. Working this out, we find

$$8\pi \mathrm{C} \log \frac{d}{\mathrm{R}} = \lambda \,.\, \frac{\cot (2\pi a/\lambda) - \tan (2\pi b/\lambda) - \tan (2\pi a/\lambda)}{\left\{ \left(\cot(2\pi a'/\lambda) - \tan (2\pi b/\lambda)\right) \tan (2\pi a/\lambda) \right\} + 1},$$

in which C is the electrostatic capacity of the condenser, d the distance between the two parallel secondary wires, R the radius of section of either, λ the wave-length, a the length from condenser to junction, a' the length from junction to bridge, and b the length of either appended wire. This equation contains no unknown terms except λ.—If the condenser be suppressed, we have the case of the junctions placed between two bridges, in which case

$C = \infty$, and

$$\cot(2\pi a/\lambda) + \cot(2\pi a'/\lambda) = \tan(2\pi b/\lambda).$$

If there be no appended wires we have $b=0$ and

$$8\pi C \log \frac{d}{R} = \frac{\lambda}{\tan\left(2\pi(a+a')/\lambda\right)},$$

which, making $a+a'=z$, coincides with the formula of Cohn and Heerwagen; and further,

$$\cot(2\pi a/\lambda) + \cot(2\pi a'/\lambda) = 0;$$
$$\therefore \quad \sin\left(2\pi(a+a')/\lambda\right) = 0;$$

or $(a+a')=z$, the length of the wire from condenser to bridge, is a whole number of half wave-lengths.—Tabulated experimental results, showing how the primary wave-length differs according to the length of the appended wires, amply confirm the formula given. The variations in this wave-length are small in comparison with the original wave-length. As the distance between the bridge and the condenser goes on increasing, a limit is reached at which the wave-length is the same as if there had been no condenser in the circuit; and then there are nodes at the condenser. On using the bridge as a source, experiments with appended wires and a bridge beyond the first bridge give results which confirm the formula for the case of the suppressed condenser. A. D.

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170. *Coexistent Electrical Vibrations in the Blondlot Apparatus.* **D. Mazzotto.** (N. Cimento, 4. 6. pp. 186–191, 1897.)—In the Blondlot apparatus (C. R. 114. p. 283, 1892), as in the Lecher (see preceding Abstract), there are waves produced whose length differs with the position of the first bridge, and shorter secondary waves; but there are also still shorter or tertiary, and occasionally again still shorter or quaternary waves. These sets of waves are in general far from presenting harmonic ratios between their frequencies. The length of these waves varies continuously but according to different laws, as the first bridge is shifted along the secondary wires. There are positions of the bridge in which there appear to be incompatibility between the proper vibration in the primary circuit and the secondary vibration, so that the latter is produced not at all, or only very feebly. The period of the primary vibration, when the first bridge is near the exciter, agrees sensibly with the Thomson formula; and it increases equally, whether with increase of the capacity or with the self-induction of the exciting circuit. The period of the secondary vibration depends much less than the former upon the capacity of the exciting circuit, but it increases very rapidly with the self-induction of the exciter or of the secondary circuit. A. D.

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171. *Secondary Waves from Dielectrics.* **A. Righi.** (Mem. R. Accad. della Sci. dell' Istit. di Bologna, 5. T. 6.)—If a non-conductor be placed in a dielectric traversed by electromagnetic waves, and if there be a difference between the dielectric constants of the substances, the body immersed—behaving like a resonator—acts as the source of secondary waves. The cases where the bodies are spheres or cylinders are worked out in some detail.
A. Gs.

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172. *Kathode Rays.* **A. Battelli** and **A. Garbasso.** (N. Cimento, 4. 6. pp. 5–8, 1897.)—Kathode rays, when they traverse a material obstacle, traverse it with all their original properties; and if they are modified in their behaviour, this is due to the changed conditions of the surrounding medium. A. D.

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173. *Valve Action in Vacuum Tubes.* **E. Hagenbach.** (Annal. Phys. Chem. 63. pp. 1–8, 1897.)—Investigates the difference in the current-strength of vacuum discharges in different directions between a point and a disc. The discharge is a single spark from the secondary of an induction-coil, and is measured by a ballistic galvanometer inserted in the secondary circuit. Eighty different pressures are employed. When the disc is the anode, the current increases until the pressure is reduced to 10 mm. A minimum occurs at 0·08 mm., and after that the current increases slightly, probably owing to the generation of X-rays. When the point is the anode, the maximum occurs at 2·68 instead; and at that point the current is more than twice as strong as it is in the reverse direction. At very low pressures the case is reversed, and the current proceeds with greater ease from the disc to the point than in the reverse direction. E. E. F.

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174. *Stratified Discharge in Open Air.* **M. Toepler.** (Annal. Phys. Chem. 63. pp. 109–116, 1897.)—A well-defined stratification of the ordinary spark-discharge in air may be brought about by interposing a semi-conducting plate of dry slate, granite, syenite, or basalt in its path. The discharge is best obtained from an influence-machine through a circuit containing a large water-resistance, which prolongs the spark to a duration of about $\frac{1}{4}$ second. The author used a voltage of 80,000, obtained from one of his 60-plate machines. It is important to notice that the stratifications are seen next the kathode, and not in the positive light, as in vacuum discharges. Sometimes as many as 6 strata are seen, separated from the white surface on the kathode by a very narrow dark space, corresponding evidently to the dark space observed in vacuum tubes. The strata retain a fixed distance from the kathode, however the latter or the semi-conducting plate may be shifted. They correspond roughly to equipotential surfaces round the kathode. E. E. F.

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175. *Screening Effect of Luminescent Gases.* **E. Wiedemann** and **G. C. Schmidt.** (Annal. Phys. Chem. 62. pp. 460–467, 1897.)—If rarefied gases are made to glow by oscillating currents in their vicinity, the greatest luminosity proceeds from the portions of the gas next the exciter, the rest being screened by the glowing gas. The authors placed a vacuum-tube with electrodes against the terminal condenser-plates of a Lecher wire system. This tube was exhausted until it exhibited a considerable dark space about the kathode. On placing a small electrode-less tube behind it, the latter responded to the glow when placed behind the dark space, but not behind the positive light column. When the pressure was reduced to the extent of filling the whole tube with kathode rays, it exerted no screening action on the waves proceeding from the Lecher system. On the other hand, no screening action could be produced by a fish-tail gas-burner, nor a Bunsen burner by itself, nor a Bunsen burner coloured by sodium or lithium salts. Vacuum-tubes traversed by high-voltage currents screen against electrostatic forces. This screening is probably due to electrostatic charges on the tube-walls due to transverse currents across the tube produced by the slight difference of potential due to the presence of the charged body. Similar transverse currents may also account for the electrostatic deflection of kathode rays observed by Jaumann. E. E. F.

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176. *Canal Rays.* **E. Wiedemann** and **G. C. Schmidt.** (Annal. Phys. Chem. 62. pp. 468–473, 1897.)—The canal rays, discovered by Goldstein, form the first kathode layer, and may be studied by perforating the kathode. The authors describe a convenient set of tubes for obtaining them. A compound tube is separated into two compartments by a transverse partition of wire gauze or grating, which also forms the kathode. Anodes are inserted at both ends, and on connecting up one of them, canal rays are obtained in the opposite compartment. In another pattern, the tube contains two successive partitions, and the canal rays are obtained in the space between them. Both types of tubes should be narrow. The spaces containing canal rays exert a screening action upon electric waves, similar to that exerted by luminous gas discharges. They also reduce the discharge potential, as may be proved by a spark-gap mounted in parallel with the two partitions. It may be more strikingly proved by attaching a side tube with a perforated kathode to the main tube in such a manner that the canal rays from the side tube fall upon the main kathode. The discharge potential in the main tube is thereby considerably reduced. If electrodes of plain wire are introduced into the path of the canal rays, transverse currents are considerably facilitated by their influence, both in the case of discharges from an influence machine and from a battery. E. E. F.

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177. *Discharge across Small Air-gaps.* **E. Salvioni.** (Atti dell' Accad. Medico-Chirurgica di Perugia, 9. 3. 1897.)—Two small spheres of amalgamated platinum (obtained by passing an electric arc from a platinum wire to the surface of mercury) are attached to platinum wires which are fixed by insulating material to a frame of copper made by bending a plate twice at right angles. The apparatus is placed in a brass box with double walls: by means of a water-jacket the temperature of the interior may be changed; and then, in consequence of the different rates of expansion of platinum and copper, the distance of the spherules may be altered. To determine the temperature of the copper frame a thermo-electric couple is used; and in the circuit is placed a battery of 300 Volta elements and a Nobili galvanometer. Starting with so high a temperature that no current passes, it is found that as the temperature sinks a moment comes when the circuit is *just* closed by 300 elements; then later on it is just closed by 200, and so on until finally two elements only suffice to close it. It is found that when the current from a certain number of elements has actually passed, that from a much smaller number will also pass: this state of extra conductivity is permanent, but may be removed by mechanically disturbing the apparatus. When the temperature is such that the circuit is not closed but the critical point is nearly reached, a very slight mechanical disturbance produces discharge and the passage of electricity continues. The apparatus is a sort of elementary "coherer." The author calculated the distances of the spherules for the different temperatures by the method of fringes, and found distances extraordinarily small as compared with the smallest found by Lord Kelvin (corresponding to the spark between two slightly curved planes). G. B. M.

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178. *Potential of Spark Discharges.* **R. Swyngedauw.** (Comptes Rendus, 125. pp. 863–865, 1897.)—In this note the author briefly defends his work (see Phys. Soc. Abstracts, No. 540, 1897) against an attack made on it by Jaumann, the more complete reply being reserved for another occasion. E. H. B.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

179. *Molecular Volumes of Liquids.* **R. Nasini.** (Roma, R. Accad. Lincei, Atti. 6. 2. pp. 199–208, 1897.)—The papers contain a thorough examination and criticism of some laws which have from time to time been enunciated by Traube. A. Gs.

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180. *Atomic Weights of Argon and Helium.* **H. Wilde.** (Comptes Rendus, 125. pp. 649–651, 1897.)—The number for argon deduced from its specific heat is 40, which would bring it in the periodic system into the position already occupied by calcium, an element with which it has no more analogy than it has with the families on each side of it. On the other hand, its relationship to nitrogen being similar to that of ozone to oxygen, the author has attempted to effect the conversion of the one into the other. Dry atmospheric nitrogen at -76° C. and 1 mm. pressure was submitted to the silent discharge for 8 hours without any change in the spectrum. Strong induction-sparks between various metallic electrodes at 20 atmospheres pressure, and also under other conditions, had equally negative results, thus indirectly supporting the elementary character of argon. In M. Wilde's table of elements, founded on multiples of their atomic weights, nitrogen ranks as $2H \times 7$, and argon, if its atomic weight be 21, as $3H \times 7$, silicon being the next member with $4H \times 7$. Ramsay and others have placed helium between H and Li, although such a position would necessitate either another horizontal series of at least 7 members, or the displacement of the vertical series, introducing further confusion into the "pretended periodic system." M. Wilde classes helium as $H \times 2$, at the head of the second series in his table (Manchester Memoirs, 1878, 1886, 1895).

See also C. R. 120. p. 584, 1895; Phil. Mag. 40. p. 466, 1895; B. A. Report, 1897; Nature, Aug. 19, 1897, p. 380. S. G. R.

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181. *Vapour-Pressure of Efflorescent Hydrates.* **G. Tammann.** (Annal. Phys. Chem. 63. pp. 16–22, 1897.)—The investigation dealt with those solid hydrates which, like magnesium platinocyanide, remain transparent during efflorescence. The substances were suspended in glass pails inside bottles containing sulphuric acid of known strength, and were weighed at intervals until equilibrium was established. The curves obtained show that the behaviour of zeolites, like heulandite, chabasite, and desmine, differs from that of $MgPtCy_4 + 7H_2O$. The diminution of vapour-pressure with loss of water in the latter is slow at first, and afterwards very rapid, whereas the reverse holds for the zeolites. The author thinks that the zeolites are admirably adapted for

serving as semipermeable membranes in osmotic pressure measurements, since they will assume the vapour-pressures of any solutions with which they may be in contact. E. E. F.

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182. *Combination of Hydrogen with Oxygen.* **Berthelot.** (Comptes Rendus, 125. pp. 675–679, 1897.)—An account is given of the results of experiments made to find if compounds which readily absorb water exercise any influence on the combination of hydrogen with oxygen. It was found in each case that the presence of hydrochloric acid gas, fluoride of boron, dry sulphurous acid gas, and phosphoric anhydride did not exercise any marked influence on the combination. The action was *nil* at 100° and but slight at 280°. In the case of sulphuric acid which is reduced by hydrogen, all the hydrogen disappeared in 5 hours when the temperature was 280°. A small fraction of the oxygen also disappeared, but this may have been taken by the sulphurous acid. The presence of these substances must have made the combination more active, if this combination was regulated by an equilibrium limited by the presence of the vapour of water, whether the combination is susceptible of becoming total or not. The result observed is explained better if the combination is unlimited but excessively slow at 280°. J. J. S.

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183. *Artificial Diamond.* **Q. Majorana.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 141–147, 1897.)—In Moissan's method carbon is highly heated under great pressure and assumes the denser crystalline form whose sp. gr. is 3·5 as against, say, 2·5 for graphite and less than 2 for amorphous carbon. The carbon softens under the high temperature to which it is exposed, a fact known since Despretz's experiments: and it is easy to demonstrate this by passing a heavy current through an arc-lamp carbon, which becomes flexible. Moissan's method leaves it doubtful, however, whether the solubility of the carbon in the chilling metal may not have something to do with the result. The author applies a more direct method of heating and then applying pressure. The heating is effected by the electric arc: the pressure is applied by explosives. The apparatus, which is described, stands 5000 atmos. pressure. One blow raised the specific gravity from 1·52 (sugar carbon) to 2·28, and the appearance was that of laminated graphite. On powdering the mass and treating it with boiling hydrochloric acid in order to remove any iron, and then alternately with aqua regia, sulphuric acid, and hydrofluoric acid in order to remove any amorphous carbon; then with chlorate of potash and nitric acid to remove graphite; and finally washing with hydrofluoric acid and boiling sulphuric acid,—a residue was obtained, very small in quantity. On this being shaken with bromoform (sp. gr. 2·9) and iodide of methylene (sp. gr. 3·3), a still heavier residue was left, consisting mainly of broken black diamond crystals with some

clear ones: all hard, powerfully refractile, isotropic, with facets or sometimes a mammillary surface, and burning completely in air when raised to the required temperature, with the characteristic appearance of the combustion of diamond, namely, that the mass first grows smaller as if it were subliming, and then minute particles rise from it, tremble in the surrounding air, and then disappear. A. D.

184. *Chemical Composition and Physical Properties of Liquids.* **E. van Aubel.** (Journ. de Physique, 6. pp. 531–535, 1897.)—Discussing various series of physical constants, the author concludes: It is not the case that isomers possess nearly the same coefficient of thermal dilatation; the differences are sometimes very great. The substitution of chlorine for H or HO in a molecule diminishes the thermal conductivity, increases the density, and lowers the specific heat and the latent heat of vaporisation: with bromine the effect is greater, and with iodine the effect is still more marked. Passing from an alcohol to the corresponding fatty acid, the density and the thermal conductivity go up while the specific heat and the latent heat of vaporisation fall; but for the higher terms of the series the thermal conductivity undergoes no change. A. D.

185. *Osmotic Pressures of Sugar Solutions.* **A. Ponsot.** (Comptes Rendus, 125. pp. 867–869, 1897.)—The osmotic pressures of solutions of cane-sugar are measured directly by means of Pfeffer's method. The height is measured at which the liquid stands in a glass tube attached to the semipermeable cell when equilibrium is attained. In order to maintain a constant temperature the apparatus is set up in a well below the physical laboratory of the Sorbonne. A solution containing 1·235 grams of sugar per litre, at 11°·8 gave osmotic pressures varying from 867 to 873 mm., three different cells being used. At 0°·8, the same solution gave 846 mm. A solution containing 0·6175 gram per litre gave, at 11°·8, 433–444 mm. The pressure of a perfect gas of the same concentration and temperature as the stronger solution would be 870 mm. T. E.

186. *Energy of Bases of Mixed Function.* **G. Carrara** and **U. Rossi.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 152–158, 1897.)—The term "bases of mixed function" is intended to cover such bodies as contain in their formula an acid and basic term such as glycocoll. The authors give the chemical grounds for the formula usually assigned to glycocoll, betaine, and other bodies. They discuss the possibility of the internal saturation of the molecule, particularly with regard to the theory of electrolytic dissociation. They then consider the grounds for regarding the conductivity of solutions as a convenient method of investigating the properties of these weak bases. They discuss the general expressions for the amount of dissociated salt in terms of the constants of affinity.

A. Gs.

187. *Electrolytic Conductivity of Bases of Mixed Function and of their Hydrochlorates.* **G. Carrara** and **U. Rossi.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 208–216, 1897.)—The authors give in this paper the numerical values of the conductivity of various solutions, with the physical deductions in tabular form. They discuss salts of betaine, and other bodies of that nature. A. Gs.

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188. *Electrolytic Conductivity of Liquid Ammonia Solutions.* **H. P. Cady.** (Journ. Phys. Chem. 1. pp. 707–713, 1897.)—The similarity existing between certain salts containing water of crystallisation and similar salts containing ammonia, has suggested the idea that water and ammonia might be analogous in some other properties, *i. e.* ionising power. The liquid anhydrous ammonia used in these experiments was the ordinary commercial ammonia used for the manufacture of ice, and was contained in a vacuum-jacketed test-tube, closed by a doubly-bored cork which supported two platinum plates as electrodes. A potential of 12 volts did not produce an appreciable current through the pure ammonia. 110 volts cause only a few hundredths of an ampere to flow, and the ammonia boiled vigorously. A small quantity of a soluble salt made a solution which conducted well, and in the case of sodium or potassium salts the solution becomes blue, but it becomes colourless when the current is stopped.—Metallic salts, *i. e.* Ag, Cu, Ba, give deposits of the metal on the kathode. Potassium iodide gives a dark grey deposit, probably KNH_2, on the kathode, and on the anode a bluish-black to olive-green explosive deposit, probably NH_3I. A solution of Na in ammonia conducts well, no deposit is formed on the electrodes and no gas is evolved. There is no polarisation current. The solution apparently conducts like a metal, and not as an electrolyte. A table is given of the values of conductivities at $-34°$. The author considers that ammonia possesses the same ionising power as water, and in many cases the ions travel faster in it than in water. S. S.

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189. *Chemical Action of Electrical Oscillations.* Part II. **A. de Hemptinne.** (Zschr. Phys. Chem. 23. pp. 483–492, 1897.)—The action of electrical oscillations on chemical compounds having been proved to be akin to that of sparking (Phys. Soc. Abstracts, No. 637, Oct. 1897), the influence of the wave-length is investigated by ascertaining the limiting pressure at which the tube remains luminous with waves of different periods. With methyl and ethyl alcohol the pressure increases with the wave-length, but with allyl alcohol and propionic aldehyde no alteration is observed, whilst with acetone it varies in an irregular manner. The slight variation in the spectra of the compounds as the wave-length is altered, is more probably due to the presence of varying amounts of decomposition products than to any direct action.

The author is investigating the effect of temperature on the limiting pressures, which appears to be considerable. A magnetic field is without action. J. W.

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190. *Ozone.* (Elect. Rev. 41. pp. 601–603, 1897.)—The article gives a brief general description of the Yarnold apparatus for the production of ozone. The cost is stated to be less than 1*d.* per 2000 cubic feet of ozonised air (taking the cost of electrical energy at 4*d.* per unit). The principal practical applications of ozone are then explained. It has been successfully applied to the cleansing of brewers' foul casks; the drying and thickening of linseed and other oils; the seasoning of linoleum, and the manufacture of hydrogen peroxide. It may be used for the sterilisation of water, and is in general a powerful agent in sanitation. It has been found to alleviate the distressing symptoms in cancer and malignant growths by destroying the offensive smell. There are possible uses for it in metallurgical operations. A. H.

GENERAL ELECTRICAL ENGINEERING.

191. *Fuses and Circuit-Breakers.* **W. M. Stine.** (Amer. Electn. 9. pp. 350–351, 1897.)—From a series of experiments performed by the author, the blowing of a fuse depends upon (1) the length of the fuse; (2) the oxide film or coating which always forms, even when the fuse blows quickly, and to a very great extent when the fuse is heated up slowly, forming a tube which retains the molten metal and prevents the rupture of the circuit; (3) the condition and mass of the terminals; (4) contact with foreign substances; (5) whether the fuse is exposed or open freely to the air. The evidence of experimental tests shows that a fuse of a proper length, exposed to the air, properly placed in its receptacle, and mounted on copper terminals, is regular and reliable in its action, except where small time-constants may be of importance. The author considers that fuses should be excluded from switchboards, which should be protected by magnetic circuit-breakers; he also advocates the use of cut-outs in motor-circuits, and assures that they will open for currents not varying more than 3 or 5 per cent., being practically the same for creeping and impulsive currents, while their time-constant is a minute fraction of a second. W. G. R.

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192. *Fuses and Circuit-Breakers.* **F. V. Henshaw.** (Amer. Electn. 9. p. 386, 1897.)—A protective device adapted to all cases of electric lighting and power-work should satisfy the following requirements:—

(1) The circuit should open when the current reaches a fixed maximum limit, whether the increase be gradual or sudden.

(2) The device should be capable of calibration, so that the limit-current is but little in excess of the maximum normal current.

(3) In case of short circuit the line should be opened without arc or flash.

(4) Under no conditions should any part of the device become hot enough to cause damage to itself or danger to surrounding combustible material.

(5) The device should admit of the instant closing of a circuit after it has come into action to open the circuit.

(6) The device should be unaffected by variation in local temperatures or exposure or position.

(7) The design should be such as to prevent tampering by irresponsible persons, tending to change the limit of current or render the device inoperative.

In a central station conditions 1, 2, 4, 5 are required, while the others are not essential; whereas all except 5 are important on customers' premises. The author therefore concludes that for station work cut-outs are preferable, while fuses are necessary for outside work. W. G. R.

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193. *Fuses versus Cut-outs.* **H. H. Cutler.** (Amer. Electn. 9. pp. 305–306 & 385–386, 1897.)—These are two articles in which the advantages of fuses and the disadvantages of magnetic cut-outs are discussed. When magnetic cut-outs are placed on circuits in which an excessive current is only an occasional accident, they become clogged with dust and dirt, and when the accidental occasion does arrive they allow excessive currents to flow and perhaps refuse to act at all. Another strong objection urged against them is that, if they do act at the right moment, the interruption of the current is too sudden; and if they happen to be placed in, say, a shunt-motor circuit, in which there is a large self-induction, the sudden break gives rise to abnormal electromotive forces which are liable to damage the insulation or even break it down altogether.

In enumerating the requirements of a good circuit-breaker, the author states that (1) the initial movement should not open the circuit; (2) it should introduce sufficient resistance into the circuit to cut down the current to a safe amount, and then open the circuit; (3) it should introduce this resistance instantly only when the flow of current is extremely abnormal; (4) it should not act at all on a flow of an abnormal current lasting only for a short interval of time; (5) it should act when a slightly abnormal current continues for a long time; (6) the time which elapses before it starts to open should be governed by the temperature of the electrical devices which it protects; (7) whenever possible it should divert abnormal currents from going through the apparatus to be protected.

The function of the ideal circuit-breaker is to protect electrical apparatus from heating effects and from inductive effects or power to break down insulation. Both of these requirements bring in the element of time, upon which the ordinary magnetic cut-out does not depend at all. W. G. R.

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194. *An Accurate and Reliable Fuse.* **L. W. Downes.** (Amer. Electn. 9. pp. 386–389, 1897.)—This is a description of a fuse which the author has found to be a reliable one. It consists of an ordinary fuse-wire soldered to copper terminals, and at the middle of its length is placed an air-drum, the wire being threaded through it. The whole is placed in an enclosure and packed with some kind of filling the composition of which is not stated. Sand was tried and found unsatisfactory. W. G. R.

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195. *Insulators for High Tension.* **J. R. Haskin.** (Elect. World, 31. pp. 122–123, 1898.)—This article gives an account of the method employed for testing the porcelain insulators on the Niagara-Buffalo long-distance high-tension system of electrical transmission. It resembles the ordinary test used for telegraph insulators, but is much more severe. The insulators are placed in an inverted position in a square iron pan, the bolt-holes and the spaces between the cups are filled with salt water, and the current from a transformer is applied at from 20,000 to 40,000 volts. If

there is a flaw in the insulator, it is at once manifested by a yellowish spark. Experiment shows that when fresh water is used instead of brine, a much larger proportion of the insulators pass the test, but of these a great many develop subsequent faults. Of those that withstood the brine-test not more than 3 in 12,000 have failed on the Buffalo line. The author is therefore strongly in favour of brine. A rough estimate of the quality of a given sample of porcelain can be made by observing the effect of red-ink upon it: any porosity is at once revealed. In some parts of Western America power is transmitted at 50,000 and 60,000 volts on wires insulated only by the ordinary telegraph insulator of *glass*. In such districts the air is of course exceptionally pure and dry.

R. A.

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196. *Automatic Transformer-Switch.* **G. G.** (Écl. Élect. 14. pp. 164–165, 1898.)—The most effective method of reducing the light-load losses of transformers consists in switching them out as the load diminishes, so that all the transformers which remain in circuit are kept working at full load and high efficiency. Mr. Schlatter, of Budapest, has for this purpose during the last two years used a type of automatic switch which has given satisfaction. The method involves the use of a small auxiliary transformer whose primary and secondary are respectively joined in series with those of the main transformer. Included in the secondary circuit of the transformers is an electromagnet which acts on a mercury switch. The latter is closed as soon as the smallest current appears in the secondary, and short-circuits both windings of the auxiliary transformer. The primary of the main transformer is *always* across the mains, but since it is in series with the primary of the auxiliary transformer, and since the latter is designed so as to absorb the greater portion of the no-load power, the latter is reduced by about 95 %. The switch may be designed either for operating a single transformer or a group *en bloc*, or for throwing a bank of transformers into circuit one after another as the load increases.

[A detailed description, with illustrations, of the Schlatter switch is given in 'The Electrician' for January 14th, 1891.—*Abstractor.*]

A. H

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197. *Electromagnetic Speed-indicator.* **G. Claude.** (Ind. Élect. 7. pp. 8–9, 1898.)—This speed-indicator (L'entraineur Volta), which is primarily intended for use on cycles, comprises a metallic disc mounted on an arbor turning on jewels, etc. This arbor is provided with a pointer moving over a graduated scale, and its motion is controlled by a hair-spring. On opposite sides of this disc are arranged magnets mounted on a frame adapted to be rotated by the object whose speed is to be measured. These magnets cause Foucault currents to be generated in the disc, and so produce a torque on its arbor, this torque being proportional to the angular velocity of the magnets and being balanced by the

hair-spring. If desired, the instrument can be combined with a counter for registering the total number of revolutions of the magnets or a number proportional thereto. C. K. F.

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198. *Electric Lift.* **F. Hérard.** (Électricien, 15. pp. 65–69, 1898.)—This lift consists of a cabin supported by a cable which is provided with a counter-weight, and is passed over the drum of an electrically-operated winch used solely for raising the cabin. In order to render the lift as safe as possible, the cabin is provided at its underside with a tubular steel piston passing down into a cylinder containing water and in communication, through a controlling-valve, with a storage tank. This water serves to fill the space left as the piston rises, so that, when the winch stops, the cabin, through the medium of its piston, can be allowed to rest on the column of water in a perfectly stable manner. The descent is effected automatically under the combined action of the weight and of the hydraulic brake formed by the piston and cylinder. The valve controlling the inlet and outlet of the water to the hydraulic cylinder and the resistance-switch for the electric motor of the winch are coupled together by linkwork, and actuated simultaneously by means of a lever operated either by a cord passing through the cabin or by a rod at the landing-stages. This interconnected system is actuated partly by hand and partly by the action of a rolling-weight, so as to ensure that the motor shall always be started uniformly, an oil-cataract being provided for preventing violent motions of the valve-lever. The authors give figures showing that with a useful load of 210 kilos and lift of 16 metres, a single complete operation costs 0·021 franc. This system is due to Guyenet and De Mocomble. C. K. F.

DYNAMOS, MOTORS, AND TRANSFORMERS.

199. *Dynamo Efficiency.* **G. Claude.** (Électricien, 15. pp. 42–44, 1898.)—The methods based on Hopkinson's original plan of circulating power between two machines suffer from the disadvantage of being applicable only in cases where two machines identical in every respect are available. The following method, recently devised by M. Routin, gets over this difficulty, and enables the losses occurring in the machine to be completely analysed. These losses are :—(1) the ri^2 losses in the armature ; (2) do. in the field ; (3) hysteresis and eddy-currents ; (4) mechanical losses (bearing friction and windage). The first two are easily calculated. The last two are obtained as follows :—Using the machine as a motor, run it up to a speed considerably above the normal ; switch off both armature and field-currents, and by means of a tachometer attached to the machine determine the law connecting angular velocity with time. Repeat the experiment, but using a brake with a known load on the dynamo-pulley. Plot two curves from the two sets of readings, and find the tangents of their angles of inclination α and α' to the axis of time at the normal speed. If q stand for the (known) power absorbed by the brake at this speed, then we have for the mechanical losses the value $q \tan \alpha/(\tan \alpha' - \tan \alpha)$. A third experiment is next performed, no brake being used, but the field-current, which must have its normal value, being left on. Let α'' be the new value of the angle of inclination at the normal speed. Then we get for the losses (3) and (4) the value $q\ (\tan \alpha'' - \tan \alpha)/(\tan \alpha' - \tan \alpha)$. It is to be noted that the loss (3) so obtained is somewhat less than that which occurs when the machine is loaded, the latter loss being somewhat greater on account of the field-distortion ; but in the majority of cases the error due to this cause is negligible. The brake should be arranged to absorb about 5 % of the normal output of the machine. A. H.

[See also Mr. I. R. Ashworth in a letter to 'The Electrician' of Feb. 17th, 1893.—*Abstractor.*]

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200. *Efficiency and Speed of a Dynamo.* **A. G. Hansard.** (Electn. 38. pp. 401–402, 1897.)—In determining the relation between the efficiency and speed of a dynamo it is here assumed (1) that the output is proportional to the speed ; (2) that the copper losses at full load are independent of the speed ; (3) that hysteresis and friction losses are proportional to the speed ; and (4) that the eddy-current losses vary as the square of the speed.

Let n = speed of dynamo,
Wn = output,
an^2 = eddy-current losses,
bn = hysteresis and friction losses,
c = copper losses (constant).

Then the efficiency η is given by

$$\eta = \frac{Wn}{Wn + an^2 + bn + c}.$$

Differentiating this with respect to n and equating to zero, it is found that η is a maximum when $an^2 = c$; that is, when the copper losses are equal to the eddy-current losses.

A graphic solution is also given. W. G. R.

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201. *Armature Inductance* (Discussion). **Goldsborough.** (Amer. Instit. Elect. Engin. 14. pp. 439–442, 1897.)—The main points considered in the discussion on the above paper are the variation of the inductance of an armature-coil with its position relatively to the pole-pieces, the effect of the mutual inductance of neighbouring coils, and the actual value of the self-inductance of a coil for the particular frequency at which commutation takes place. In an ordinary continuous-current armature with toothed core, the inductance of a coil is practically constant for any position under the pole-faces, and diminishes considerably for positions in the interpolar space. C. P. Steinmetz states that the mutual inductance of neighbouring coils produces no appreciable effect—unless two coils happen to lie in the same slot. He further points out that if the inductance of an armature-coil be measured by the method of reversals or by alternating currents of ordinary frequencies, the value so obtained is very much higher than that corresponding to frequencies from 500 to 1000 cycles per second. It is this latter value which has to be considered in dealing with commutation, as the frequency in such cases usually amounts to between 400 and 800. The smaller value for the higher frequency is due to the fact that for high frequencies the field-structure which is in the magnetic circuit of the coil under commutation is, on account of its solidity, incapable of responding to a rapidly varying magnetic force, the varying magnetic flux being constrained to pass through the air-gap across the top of the slot. A. H.

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202. *Single-Phase Motors.* **E. I. Berg.** (Amer. Electn. 9. pp. 204–205, 1897.)—The author briefly discusses the relative merits of different forms of single-phase motors, and gives data and curves relating to the performance of a 100-HP. single-phase induction-motor recently constructed by the General Electric Company. The motor has 12 poles, runs at 600 revs., and is wound for 2000 volts. The speed remains remarkably constant, the drop at full load being only 1·5 %. The following table shows the variation of the efficiency and power-factor with the load :—

Percentage of normal load......	25	50	75	100	125
Efficiency	68	81	84·5	82	82
Power-factor, per cent.........	43	62	72	76	78

The maximum output is 50 % in excess of the normal load. The starting device consists of a reactance coil connected in series with a non-inductive resistance, the two being joined across the mains. The mains and the junction of the two coils mentioned are connected respectively to three points in the winding of the motor. The latter is thus started as a multiphase motor, and the starting device is cut out when the motor has run up to its normal speed. No constructional details are given. A. H.

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203. *Rotary Converters.* **R. B. Owens; D. W. Hawksworth** and **H. W. Doubrava.** (Amer. Instit. Elect. Engin. 14. pp. 385–396, 1897.)—This is an endeavour to investigate the effect of armature reactions in a rotary converter by obtaining curves showing the instantaneous distribution of induction over the pole-faces for different armature positions and conditions of loading. The method employed consists in measuring the instantaneous electromotive forces under different conditions generated in a series of equal evenly spaced coils of fine wire wound over the armature surface. The machine experimented upon is of the consequent pole type, having an output of 3·5 kilowatts at 110 volts and at a speed of 2400 revolutions per minute per minute. The machine was originally a continuous-current generator with a 54-part commutator, and was changed into a three-phase converter by placing slip-rings on the armature-shaft and connecting segments 1, 19, and 37 of the commutator respectively to rings 1, 2, and 3. No suitable tri-phase generator being available, it was used only to convert continuous into three-phase currents.

The machine was first run light as a motor, and a curve was obtained showing the induction distribution to be quite uniform over the polar surface, but slightly shifted in the direction opposite to rotation. When run as a motor on full load with an armature current of 32·6 amperes, the curve obtained shows a decided distortion of the field. When run as a rotary converter with the three limbs equally loaded with incandescent lamps, the armature current being 39·45 amperes, no shifting of the brushes was necessary to avoid sparking showing the small reactions in a rotary converter, and the curve shows uniformity of distribution of induction over the polar face. When run as a rotary converter with inductive load, very slight alteration of the curve is noticed.

Curves showing the E.M.F.'s between the legs of the rotary for different loads are given, as also are efficiency curves for the machine run as a motor and a converter.

In the discussion on the paper Mr. Dunn draws attention to the high resistivity of cast-iron as being four or five times that of steel.

Mr. C. P. Steinmetz remarks that in a polyphase rotary converter the resultant armature reaction of the machine as direct-current machine and as alternating-current machine are equal but opposite, thus neutralising each other, and all that remains of armature reaction are effects of higher harmonics which may be

called higher harmonics of armature reaction. When the converter is used to change from alternating to direct current, further higher harmonics exist due to the difference in the wave-shape between the applied potential difference and the induced alternating counter E.M.F., which difference causes a current component consisting essentially of waves of higher frequency. W. G. R.

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204. *Rotary Transformers.* **J. E. Woodbridge** and **C. T. Child.** (Elect. World, 31. pp. 12–14, 1898.)—The object of this paper is to calculate the copper losses in a rotary converter. To simplify the mathematics it is assumed that the converter is working in such a condition that its power-factor is unity, and losses due to hysteresis, eddy-currents, and friction are neglected, so that the input may be taken to be numerically equal to the output.

Let V be the direct-current voltage and C the direct current in one path through the armature, so that the total external direct current is 2 C. The maximum instantaneous alternating voltage is then V, and the maximum alternating current is 2 C. If the converter is a single-phase one and if α is the angular distance of an armature-conductor from the point midway between the alternating current tappings, it is shown that the rate of heating of this conductor whose resistance is r is $C^2r\left(3-\frac{8}{\pi}\cos\alpha\right)$, and the average heating effect is

$$\frac{C^2r}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\left(3-\frac{8}{\pi}\cos\alpha\right)d\alpha=C^2r\left(3-\frac{16}{\pi^2}\right)$$

$$=1\cdot38C^2r.$$

Thus it is seen that, under the conditions assumed, any direct-current machine used as a single-phase rotary will dissipate in copper losses 38 per cent. more energy than when working simply as a direct-current machine at the same output. To determine, therefore, the safe load of a machine with known generating capacity when worked as a single-phase rotary, let K be this safe transforming current-capacity; then

$$1\cdot38\ K^2r=C^2r;$$

that is $$K=0\cdot85\ C.$$

Hence, with unity power-factor, the rating of a single-phase rotary transformer should be 85 per cent. of that of a direct-current generator or motor of the same dimensions.

If the power-factor of the rotary is taken to be 0·8, the value of K is calculated to be 0·63 C. W. G. R.

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205. *Hysteresis Losses.* **F. Drouin.** (Électricien, 14. pp. 300–301, 1897.)—M. Lional Fleischmann showed some time ago how to

determine the R.M.S. value of an E.M.F. by a method depending on the properties of the centre of gravity of an area. Thus if e_1 is ordinate of the C.G. of an E.M.F. curve, and e its instantaneous value,

$$e_1 \int e dt = \tfrac{1}{2} \int e^2 dt,$$

whence

$$\sqrt{\frac{1}{T}\int_0^T e^2 dt} = \sqrt{\frac{1}{T} \cdot 2e_1 \int_0^T e dt},$$

where T is half the periodic time of the E.M.F.

Now if N is the maximum value of the total flux through an iron core due to a current flowing through n turns of wire wound round it, we have

$$\int_0^T e dt = Nn.$$

Thus

$$\sqrt{\frac{1}{T}\int_0^T e^2 dt} = \sqrt{\frac{2}{T} \cdot e_1 nN}.$$

The hysteresis loss depends only on N. If, then, there are two differently shaped E.M.F. curves having the same R.M.S. value, we have

$$e_1 N = e'_1 N',$$

where e_1 and e'_1 are the ordinates of the centres of gravity of their areas, and N, N$'$ the corresponding values of the total flux; whence

$$\frac{N}{N'} = \frac{e'_1}{e_1}.$$

Assuming now the empirical law of Steinmetz, we see that hysteresis losses should vary inversely as the 1·6th power of the distances of the centres of gravity of the area of the E.M.F. curve from the axis of time.

Applying this to the case in which the E.M.F. curve is triangular or rectangular, the author finds that a rectangular E.M.F. curve causes hysteresis losses 1·182 times, and a triangular curve 0·937 times that due to a simple sine curve. W. G. R.

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206. *Converting Tri-phase into Mono-phase Currents.* **J. Lefèvre.** (Ind. Élect. 7. pp. 9–10, 1898.)—In this apparatus, due to Grassi and Civita, the three primary currents act on three separate coils of which the windings are united into a single circuit. The apparatus comprises three straight parallel cores, A, B, C, connected by two yokes. Each core carries two coils, one primary, the other secondary. The three secondary wires are connected in series, but the winding of C should be in the opposite direction to that of A; as regards B, the direction is immaterial. If the three primary

coils are wound in the same direction, it will be found, on closing the secondary, that the three primary currents are always of different amounts, it being the same with the amounts of energy absorbed. In a modified form, say 310 turns of wire are wound on each of the cores A and C, and for the central core B the diameter is doubled and the direction of the current is changed. Under these conditions, the quantity of energy absorbed with the secondary circuit open is very small. By uniting the three secondary wires, as above mentioned, the maximum useful effect is obtained; the efficiency is high and comparable with that of ordinary transformers; the distribution of the energy in the three primary circuits is very little different. Finally, if the secondary circuit be loaded, the difference of potential in the three-line circuits will not suffer the slightest variation. Moreover, various changes can be made in these arrangements: thus two primary coils can be wound on B, arranged in series with each other and with the coils A and C; the line-wires are connected to the free ends of A and C and to the point where the two coils of B are connected together. C. K. F.

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207. *Electrochemical Rectifier.* **Graetz** and **C. Pollak.** (Elektrotechnische Zschr. 25. p. 359, & 29. pp. 423–424, 1897.)—This process is based on the fact that, when an anode of aluminium is employed in an electrolytic cell and the electrolyte is such that oxygen will be generated at this anode, the current passing will be reduced to an extraordinarily high degree. This is probably due to the formation of a very badly-conducting film of oxide on the anode, which increases the resistance of the circuit, and also to a kind of condenser action between the electrode and the liquid, or dielectric polarisation, as opposed to the ordinary electrolytic polarisation. This latter view is based on the fact that each cell of this kind has a quite definite back-E.M.F. of 22 V., so that currents of lower potential generally do not pass through the cell. On reversing the current, however, the back-E.M.F. is less than 1 V. The kathode may be of carbon, platinum, or any other usable metal except aluminium, and the electrolyte alum solutions (sodium- and potassium-alum solutions) or dilute acids which generate oxygen on electrolysis.

If an alternate current be sent through a number of these cells arranged in series, the number being such that the polarisation at the anode is greater than, or at least equal to, the potential of the alternate current, it follows that the positive part of the current, in which the aluminium is the anode, is not allowed to pass through, whilst the negative part of the current does pass through. In this manner an interrupted direct current is obtained of half the strength of the original alternate current; loss of half the energy is, however, not involved in this. By arranging another battery, having a similar number of cells but with its poles reversed, in parallel with the battery above mentioned, across the alternator terminals, the other half of the alternate current may be

obtained, a pulsating direct current then flowing *around the two branched circuits*, *i. e.* the positive current in one and the negative current in the other.

In a modified arrangement, a pair of oppositely-connected batteries are arranged at each terminal of the alternating P.D., and the other or opposite terminals of like batteries are connected together by conductors from which a direct current can be taken. By using sufficiently large cells, so as to bring down the resistance as much as possible, a maximum efficiency of 95 per cent. (energy) can be obtained (See also Phys. Soc. Abstracts, No. 673, Nov. 1897.)

A similar process was independently discovered and patented by Herr C. Pollak (Germ. Pat. No. 92564). C. K. F.

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208. *Converting Direct into Alternating Currents.* **H. S. Carhart.** (Amer. Electn. 9. pp. 121–123, 1897.)—This apparatus for converting direct into alternating currents comprises a square vessel containing a solution of $ZnSO_4$ (7–10 oz. to the quart). On two opposite sides of this vessel are arranged parallel Zn electrodes for conveying a direct current from, say, an accumulator, through the electrolyte. Into the electrolyte dip, for a simple alternating current, two zinc rods mounted diametrically opposite each other on an insulating disc at equal distances from the centre. This disc is mounted on a shaft whereby it can be rotated, and contact-rings, each connected to one of the zinc rods, are arranged on the shaft so as to engage with fixed brushes from which an alternating current can be taken. The zinc rods are arranged so as to move parallel to the zinc plates, so that, when a line joining the rods is perpendicular to the plates, the P.D. between the rods will be a maximum in one direction; when the said line is parallel to the plates, the P.D. between the rods will be zero; and when, in the continued rotation of the disc, the line is again perpendicular to the plates, the P.D. between the rods will be a maximum in the other direction; the variation of the P.D. in the intermediate positions following closely the law of sines. If four rods, arranged at angular distances of 90° from each other and connected to four contact-rings, are employed, a two-phase alternating current can be obtained; with three rods at 120° apart, and three contact-rings, a three-phase alternating current; and so on. The apparatus is chiefly designed for experimental or educational purposes; for example, in plotting P.D. curves, obtaining ratio between virtual and maximum E.M.F.'s, etc.; for which purpose the rotary shaft is provided with a pointer moving over a fixed graduated scale for indicating the angular positions of the disc and the zinc rods. C. K. F.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

209. *Power Transmission on the Continuous Current Series System.* **J. S. Hecht.** (Electn. 38. pp. 683–687, 1897.)—The author here discusses the advantages of a continuous current series system of distributing power electrically over alternating-current systems. The chief argument in favour of the former is that the switching in or out of a motor does not affect lights or other motors on the same circuit, whereas in the latter system the large starting currents and low power factors of induction motors, when running light, cause serious disturbance when switched in or out of the circuit. In the continuous current system regulation is so much easier than when working with alternating currents, that much less attention and fewer skilled attendants are required. Also the voltage difficulty is now overcome, since direct-current dynamos can now be built to give a safe working pressure of 3500 volts direct. The full main voltage is only used when required for full load, generators being switched in the circuit as the load increases. The switchboard is simple, including only ammeter, voltmeter, short-circuiting switch, and an automatic switch for cutting out the dynamo in case the pressure should rise above a certain value. No regulating rheostats are required at the generating station. Each motor on the circuit is provided with a speed regulator, two types of which are described. An account is given of the direct-current plant at Chaux-de-Fonds, which supplies power over a line of about 30 miles in length, the current having a constant value of 150 amperes at 1800 volts per generator, the total pressure being 14,400 volts. W. G. R.

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210. *Electric Power Distribution.* **M. Hoopes.** (Elect. World, 30. pp. 479–483, 1897.)—The author considers the relative advantages of systems when dealing with a section of line in which the drop is excessive and the amount of copper necessary is prohibitive. These are (1) the use of a special generator for the section; (2) the use of a booster; (3) the application of the three-wire system; (4) the use of multiphase currents and sub-stations. The value of the three-wire system for traction purposes has been much over-rated. It may often be more economical to raise the voltage on the section deficient in copper rather than introduce a three-phase network. W. R. C.

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211. *Power Transmission by Three-Phase and Continuous Currents.* **G. L. Addenbrooke.** (Elect. Rev. 40. pp. 587–588, 1897.)—The author gives a summary of the advantages and disadvantages

attending the use of three-phase as against continuous currents for the transmission of power. The cost of continuous and three-phase plant, both motors and generators, is very appreciably the same; and so also is the cost of starting resistances. With regard to the line, there seems to be a good deal of uncertainty; it would probably be impossible to estimate the exact difference in the cost of insulation of two cables, one intended for 3000 alternating, the other for 3000 continuous volts. Comparing a continuous three-wire system, with middle wire earthed, with a three-phase system (star grouping with centre earthed), and assuming the same P.D. between earth and any conductor in the two cases, it appears that the copper for the three-phase circuit is only about 78 % of that for the continuous-current one—if a power factor of 1 be assumed. On account of the power-factor in three-phase system being only about ·8, extra copper must be provided. There is thus little to choose between the two systems so far as the line is concerned. The main point of difference lies in the fact that three-phase motors can be run direct, without the use of transformers; whereas it is at present impossible to obtain continuous current motors of outputs below, say, 8 kilowatts which can be relied on to work satisfactorily at 3000 volts. For this reason three-phase currents are now available for power transmission in cases where continuous currents could not be recommended. A. H.

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212. *Three-Phase Plant of the Tide-Water Oil Company.* (El. World, 31. pp. 119–120, 1898.)—This plant has been specially designed on account of the dangers existing in using electrical devices in an oil factory. The generating consists of a 75-kilowatt 8-pole 60-cycle three-phase alternator, driven by an upright American engine with cylinder dimensions 15 × 15 inches, generating 150 horse-power at 180 revolutions per minute. Six circuits run from the power-house to different parts of the yard, three of which are two-wire for lighting purposes only, and three are three-wire for both lighting and power. The main and line voltage is 550 volts between any pair of the three wires. Fifteen motors are in use, and all are of the induction type. These are used to drive hoists, pumps, boiler-shop, tramway, and other work. In positions where an inflammable mixture of oil-vapours and air is not likely to exist, the rotors are fitted with an internal starting resistance which may be short-circuited by a hand-lever acting through a collar on the motor-shaft. For more dangerous positions the short-circuited secondary winding, pure and simple, is used; such motors being fitted with clutches or tight and loose pulleys, so that they may be started without load. The motors start with about 10 per cent. of their full rated running torque. All the motors are equipped with switches operating under oil, and the fuses are placed in boxes under the building.

The method of lighting the can-filling and freezing rooms is

interesting. These rooms, while being the most dangerous, require to be well lighted. Ninety-seven lights are used in this room, each mounted in an air-tight inclosing globe on the extremities of the heavy gas-pipe conduits. Just above each lamp there is inserted in the pipe a cast-iron box with a bolted cover, in which is placed a bug cut-out. Rubber-covered wire is used, each wire of the circuit being also further enclosed by an insulating tube within the gas-pipe protection. In this way all possible danger of a spark occurring in the open air is avoided. W. G. R.

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213. *Economics of Power Transmission.* **L. Bell.** (Amer. Electn. 9. pp. 205–207, 1897.)—This paper contains a discussion of the various factors which determine the success or otherwise of power-transmission schemes. The author works out at length a numerical example in which about 1000 H.P. is to be transmitted from a waterfall 15 miles distant. He considers the various items of cost of erection and working, and, on the basis of certain assumptions regarding probable demand for power etc., shows that the project may be made to pay. He also points out how with bad management the scheme might become a financial failure. A. H.

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214. *Power-Transmission on Warships.* **G. W. Dickie.** (Elect. World, 30. pp. 699–700, 1897.)—This is a general discussion of the relative merits of water, compressed air, and electricity for use on warships, considered with reference to safety, economy, and comfort. The paper does not call for any detailed abstract. A. H.

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215. *Electrical Plant of the Astoria Hotel.* (Elect. World, 30. pp. 751–754, 1897.)—The plant installed in this huge hotel has to supply power for over 2500 lamps, twenty-one electric elevators, and a large amount of auxiliary electrically-driven apparatus. There are six generators, four of which are 10-pole machines having an output of 250 kilowatts each, and two smaller 8-pole 100-kilowatt machines. The pressure of the current supplied to the adjoining Waldorf Hotel, which is under the same management, is raised by a special motor-driven booster. This machine is of 15 kilowatts capacity; its maximum E.M.F. is 5 volts, and its carrying capacity 3000 amperes. To provide for the efficient generation of so large a current at such a low voltage, the machine is provided with a commutator at each end of the armature. The two commutators were provided in order to provide for possible desire to boost two separate circuits; and two windings put on the armature are respectively connected to the two commutators. The machine is six-polar, and is direct-coupled to a six-pole motor, the booster field being excited by a

high-resistance winding connected across the bus-bars and controlled by a hand rheostat. The load being purely a lighting load, the hand regulation is sufficient. The commutator segments are of massive construction. The brushes are of a special construction, and consist of alternate copper and zinc leaves. A lever on either side enables all the brushes to be simultaneously raised. By means of this machine the pressure across the Waldorf Hotel feeders can be boosted 5 volts in addition to the 3 volts overcompounding of the main dynamos, the latter being sufficient for the shorter feeders of the Astoria Hotel.

W. G. R.

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216. *Overhead Trolley Car for Ordinary Roads.* **G. Dary.** (Électricien, 15. pp. 1–2, 1898.)—The article contains an illustrated description of a motor car for use on ordinary roads, the power being supplied by two overhead conductors. The car is the invention of Messrs. W. S. Caffrey and H. B. Maxson, of Leno, Nevada, U.S.A. The side-poles supporting the conductors are 7 metres high and spaced 38 m. apart; the conductors are supported on insulators placed 4·8 metres above ground and 46 cm. apart. The two portions of the double trolley are connected by lattice-work resembling a sort of pantagraph, which gives them great flexibility. The flexible conductors coming down from the trolley to the car are coiled upon a drum, so arranged that when the car leaves the direct line of the trolley-wires the flexible conductors are uncoiled; the car may thus swerve as much as 60 metres from the line of poles, and can pass from side to side of the road without difficulty. The motor used is a 2 H.P. Westinghouse one. When loaded with 1130 kilogrammes, the car easily attains a speed of 15 miles an hour.

A. H.

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217. *Patton Electric Tram Car.* (Elect. World, 30. pp. 640–641, 1897.)—The latest car made by Patton, who has adopted the Heilmann principle, is 16 feet in length. It carries a 25 H.P. gasoline engine, a six-pole 15-kilowatt Crocker-Wheeler dynamo, 200 cells of 200 ampere-hours capacity, and two 35 H.P. single-reduction motors. The battery is kept continually charged. No figures are given as to cost of running. W. R. C.

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218. *Electric Operation of Steam Railroads.* **N. H. Heft.** (Elect. World, 30. pp. 485–487, 1897.)—An account is given of the results obtained upon the New York, New Haven, and Hartford Railroad Co.'s lines. The electrically-operated part consists of 16 miles on the third-rail system and 14 miles on the trolley system. The traffic to be dealt with is heavy, and

the stops are frequent. For example, on the Nantasket Beach line there are seventeen stations in 10·6 miles. As the service is half-hourly, the run has to be made in 26 minutes, leaving only 4 minutes at the terminus, which is almost impossible of accomplishment by steam locomotives. But this service is easily carried out by means of electricity, owing to the very large accelerating-power of the motors as compared with steam locomotives. On that account, a 60-ton train reaches a maximum speed of 31 miles per hour between the stations of Windermere and Allerton, although the distance is only 1800 feet. The distance of 9·3 miles between Hartford and New Britain is covered in from 18 to 20 minutes, at an average speed of 28 to 30 miles per hour: with a highly-geared motor a maximum speed of over 60 miles per hour has been reached.

The employment of electric traction enables open summer cars to be used, as there is no annoyance from smoke. The motor-cars at present in use are 32 tons in weight and equipped with two 125 H.P. motors. The trolley has not been found to be so satisfactory as a third rail, owing to the rapid destruction of trolley-wheels by arcing, and the difficulty in keeping the wheel on the line when making speed and taking curves. The third rail, on the other hand, is generally satisfactory, although contact-shoes have sometimes been carried away at crossings. The leakage from the third rail, which rests upon creosoted wooden blocks and is at a potential of 600 volts, has been found to be inconsiderable even when there is a large amount of water on the track. No inconvenience or danger has been experienced through shocks from the third rail. It has so far been found unnecessary to use copper feeders ; the third rail is 100 lbs. per yard, and service-rails are 70 or 74 lbs., all bonded. The distance of transmission from New Britain to Hartford is 9·3 miles. There is an average loss of 26½ per cent. when two 52-ton trains are running. The cost of fuel is very low, as it is found possible to burn exclusively the half-consumed coal which is dumped from the extension front of the steam locomotives, no other fuel being employed. The author declines to make any comparison between the cost of electric and steam power for railway purposes, owing to the impossibility of doing so in a satisfactory manner. W. R. C.

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219. *Electric Power on Trunk-Line Railways.* **G. Forbes.** (Eng. Mag. 14. p. 1, 1897.)—Some particulars are given of the Niagara Falls Park and River Railway, the results at the Baltimore Tunnel, the Nantasket Beach Electric Railway, the Liverpool Overhead Railway, and the City and South London Railway. The running expenses, including repairs and renewals of carriages, of the two latter and of the Metropolitan District are as follows :—

		Weight of train.
	d.	T. cwt. lb.
City and South London	6·48 per train-mile.	37 7 0
Liverpool Overhead	3·84 " "	38 5 2
Metropolitan District	11·76 " "	157 10 0

It must be remembered that the weight of the Metropolitan train is very much heavier than those employed by the other two lines; but if the train-mileage of the latter were equal to the former, the cost of locomotive power of the latter would be reduced. An electric locomotive is capable of doing all that can be done by a steam locomotive, as shown by the results at the Baltimore Tunnel. There is no difficulty in the transmission. Where water-power is available, it is generally economical to transmit water-power hundreds of miles. It can be proved that the whole of the Scottish trunk lines might be worked electrically from water-power in that country. Taking coal at a dollar and a half per ton, electric locomotives would be cheaper than a steam railroad up to a distance of 40 or 50 miles from the power station: with water-power this distance increases on a busy line to several hundred miles. This economy is due to the fact that the best locomotives consume, even on trial tests, as much as 5 lbs. of coal per H.P. hour. Where electricity is to be worked in conjunction with steam upon an existing road, electric locomotives must of necessity be employed. But where electricity alone is to be used, the power should be applied to every axle of the train. By means of such a system the full advantages of electric traction are obtained, and the construction of the permanent way would be less costly.

W. R. C.

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220. *Rail Bonding.* **W. E. Harrington.** (Frank. Instit. Journ. 24. pp. 54–57, 1898.)—Experiments were made with various types of copper bond in combination with the Edison-Brown amalgam, which was used to improve the contact between the bond and the rail; in every case the resistance was diminished, in some instances very considerably. The resistance of the Bryan bond, consisting of a copper connection bolted to the rails, is generally much higher than that of the internal-contact type; but with amalgam in the joint it is lower than that of any bond except the Edison-Brown plastic bond. The internal bond is objectionable on account of the wearing effect of vibration and play of the rail-joint; the Bryan and Edison-Brown types are free from this defect.

The author concludes that the Edison-Brown bond is the best; the Standard bond, under the fish-plate, is very good, but difficult to place; the Bryan bond (amalgamated) is the best outside the fish-plate. Internal contact bonds should be stranded, and are improved by amalgamation. Iron-wire bonds are highly inefficient. The following table shows the resistances of various bonds :—

Kind of Bond.	Centre to Centre of Contacts.	Length of Bond.	Size of Contact.	B. & S. Gauge.	Number of Wires in Bond.	Ohms.	Per cent. Res. $=\frac{A}{B}$.
	inch.	inch.					
Joint only—no bond	36	—	—	—	—	·00071	—
Iron channel pin	45	48	$\frac{9}{16}''$ pin.	0	1	·00049	69
Bryan—Iron wire	36	39	Plate $2\frac{3}{4}''$ diam., 1″ hole in it.	$\frac{1}{2}''$	2	·000286	40
Crown	30	36	$\frac{7}{8}''$ head.	0000	1	·000247	34
Bryan—Iron wire, amalgamated..................	36	39	Plate $2\frac{3}{4}''$ diam., 1″ hole in it.	$\frac{1}{2}''$	2	·000224	31
Crown, amalgamated	30	36	$\frac{7}{8}''$ head.	0000	1	·000185	26
Bryan—Copper wire	36	39	Plate $2\frac{3}{4}''$ diam., 1″ hole in it.	0000	2	·000175	24
Columbia	30	36	$\frac{7}{8}''$ head.	0000	1	·000131	18
Columbia, amalgamated ...	30	36	$\frac{7}{8}''$ head.	0000	1	·000126	17
Stranded crown	5	7	$\frac{7}{8}''$ head.	0000	1	·0001	14
Plastic socket	$3\frac{1}{2}$	—	—	—	—	·000093	13
Bryan — Copper wire, amalgamated............	36	39	Plate $2\frac{3}{4}''$ diam., 1″ hole in it.	0000	2	·000071	9
Plastic cork	9	—	Surface $1\frac{1}{4}''$ diam.	—	—	·00006	8
Solid rail—no joint	18	There were holes in web.				·000013	—

Tests made on Penna. Steel Co. 7-inch girder rail, No. 238. A = Resistance of bond. B = Resistance of joint only.

A. H. A.

221. *Use of Accumulators in Traction.* **C. Hewett.** (Elect. World, 30. pp. 483–485, 1897.)—The author considers the application of batteries, (1) in locomotives or cars, (2) at points of the line distant from the generating station, (3) in the generating station itself. It is improbable that batteries of the lead type will be largely used in accumulator cars, either simply or on the "mixed system," owing to the inherent defects in this kind of cell. Their use may, however, be advantageous at distant points of a line when the traffic becomes too heavy for the conductors. The Union Traction Company of Philadelphia have effected a considerable saving in capital expenditure by the adoption of this method instead of increasing the feeder system. The author recommends the use of batteries in the power-house enabling the engines to be worked at maximum efficiency, instead of running with an average load of two-thirds, as is usually the case. For this purpose the battery should have a capacity equal to one-third of the maximum output of the station. Under these conditions its efficiency will be high and deterioration low. W. R. C.

222. *Accumulators for Rapid Charging.* **L. Epstein.** (Elect. Rev. 40. pp. 519–520, 1897.)—This is a critical examination of the accumulator system of electric traction advocated by M. Blanchon, who proposes to fix fairly heavy batteries permanently in the car, and of sufficient capacity for the day's total run, without, as a rule, drawing out more than two-thirds of the total capacity. This object is accomplished by a system of very rapid charging (12 to 20 minutes) at the terminus, the cells being charged not at constant current but at constant voltage. After criticising the various advantages claimed for this system, and comparing it with the usual one of exchanging batteries, the author concludes that probably a compromise between the two would give the best results. A. H.

223. *Life and Candle-power of Incandescent Lamps.* (Elect. World, 30. pp. 763–765, 1897.)—The cost of lighting is very largely dependent on the progressive drop in candle-power which occurs with all types of lamps. Many central station managers consider that a lamp has passed its *useful life* when it has lost 20 per cent. of its initial candle-power. Poor regulation of voltage causes rapid deterioration of the lamps. The following table shows the decrease in life of standard 3·1 watt lamps due to increase of normal voltage:—

Per cent. of normal voltage ...	100	101	102	103	104	104	106
Life factor	1	·818	·681	·662	·452	·374	·310

The author recommends the use of portable voltmeters for frequently determining the voltage at different points of the distributing network, and then either arranging the voltage to suit the lamps, or *vice versa*. Poor regulation is especially liable to occur in the case of alternating systems, on which the average

efficiency of lamps is 4 watts per candle. The following table gives the variation in candle-power and efficiency of standard 3·1 watt lamps, due to variation of voltage :—

Per cent. of normal voltage...	90	91	92	93	94	95	96	97	98
Per cent. of normal c.p.	53	57	61	65	69½	74	79	84	89
Efficiency in watts per candle.	4·68	4·46	4·26	4·1	3·92	3·76	3·6	3·45	3·34

Per cent. of normal voltage ...	99	100	101	102	103	104	105	106
Per cent. of normal c.p.	94½	100	106	112	118	124½	131½	138½
Efficiency in watts per candle.	3·22	3·1	2·99	2·9	2·8	2·7	2·62	2·54

The proper renewal of lamps is a matter of extreme importance from the point of view of economy. The author recommends free lamp renewals, and considers this method best for both the central station and the customer. Failing this, the next best plan would be to offer lamps at less than cost price, thus encouraging the consumer to renew his lamps at frequent intervals. The blackening of the bulbs is more often a supposed defect than a real one. A lamp may lose in candle-power and show but little blackening, and, on the other hand, the lamp may get quite black and lose very little of its initial candle-power. A. H.

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224. *Quality of Incandescent Lamps.* **F. W. Willcox.** (Elect. World, 30. pp. 698–699, 1897.)—The object of this paper is to show the folly of using cheap lamps of low-grade quality. The most rational basis of comparison is to estimate the value of a lamp in terms of the candle-hours which it is capable of giving before the candle-power falls to say 80 per cent. of its initial value. On this basis a comparison is made between two lamps of American make, from which it appears that in order to obtain the same amount of light for a given expenditure of energy from the two kinds of lamps, the cheaper one would have to be renewed about four times as frequently as the more expensive one; an initial efficiency of 3·1 watts per candle being used. Another basis of comparison is next assumed, which is somewhat better adapted to practical working conditions than the first. It consists in assuming an average life of 600 hours for each type of lamp On this basis, a comparison of four types of lamps shows that the worst type furnishes only 66 per cent. of the candle-hours obtained with the best type, the intermediate ones giving 80 per cent. and 91 per cent. respectively. When the cost of energy is taken into account, these results show in a striking manner the utter insignificance of a small difference in first cost as compared with the corresponding difference in cost of a candle-hour. A. H.

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225. *Tests of Alternating Enclosed Arc-Lamp.* (Elect. World, 30. pp. 695–696, 1897.)—The paper contains a description, illustrated by reproductions from photographs, of the appearance presented by the " Puritan " enclosed arc-lamp under various conditions of working, both normal and abnormal. The lamp takes

6 amperes at 65 volts, and the arc is found to behave like a non-inductive resistance. The normal length of arc is about $\frac{3}{8}''$; the carbons used are $\frac{1}{2}''$ Electra cored carbons; their ends remain flat, with fairly sharp edges, under normal working conditions. No data regarding the efficiency of the lamp are given. A. H.

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226. *Enclosed Arc-Lamp.* **W. H. Freedman, H. S. Burroughs,** and **J. Rapaport.** (Amer. Instit. Elect. Engin. 14. pp. 361–384, 1897.)—The authors tested a number of these lamps in order to study their characteristic features. Lamps of this type are placed singly across ordinary incandescent-lighting circuits, and are regulated to take approximately 80 volts across the arc, the rest of the potential being consumed in the regulating solenoid and extra resistance which are in series with one another. The standard current is 5 ampères, the arc being about $\frac{5}{16}''$ long, while the carbons burn nearly flat instead of taking the shape as in the case of the open arc, the arc wandering round the flat ends. The simplest form of friction clutch consists of a straight horizontal rod fastened to the end of the plunger of the solenoid, and having at each end an arm so pivoted that these two arms cross each other like a letter X. At each lower end of these arms is pivoted a friction piece of round or V-shaped surface that grasps the rod holding the upper carbon. Lifting the upper ends causes the lower ends to grip the rod. When the device falls far enough, it touches a stop and releases the carbon-holder. Another form of clutch consists of a series of steel balls resting on a grooved piece around the carbon-holder, and adapted to be pressed against the holder by a conical cup actuated by the plunger of the regulating solenoid. The brass rod carrying the upper carbon requires to be cleaned after each run (75–150 hours). The life of the carbons was found to be promoted by keeping the enclosing globe as small as possible. The positive carbon is consumed at the rate of about 0·05 in. per hour and the negative at half this rate. When burning at 80–85 V., the variation in the current is very considerably less than with an open arc. In one case the extra resistance was 6 ohms, that of the solenoid coil 1 ohm, normal voltage 115. The movable carbon enters the enclosed globe through a gas cap or check which obstructs the circulation of air as much as possible, but admits sufficient air to prevent excessive deposition of carbon on the globe. It consists generally of a plug fitting closly inside the top of the globe, and provided with a central tube through which the carbon passes freely, this tube having internal circumferential channels or grooves or slits opening into an intermediate air-chamber.

The distribution of the light is different to that obtained from an open arc. With the enclosed arc the maximum intensity is at an angle of 25° below the horizontal, and after a decrease another high value is obtained at 40°. For two clear glass globes, the watts per candle are about 0·5; with opal inner and clear outer, watts per

candle 0·56 to 0·60; with both inner and outer opal, watts per candle 0·9 to 1, *i. e.* mean *hemispherical* candle-power. Also the efficiency from the use of a holophane globe was but little less than that of an ordinary clear globe (absorptions 9–13 per cent. and 5–8 per cent. respectively). The colour of the light was violet around the horizontal plane and white below it. If the arc be allowed to form too high up in the globe, deposit of carbon will take place. C. K. F.

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227. *Electric Meters.* **C. D. Haskins.** (Elect. World, 31. pp. 31–33, 1898.)—The author first advocates the use of small meters, preferring rather to lose an occasional meter by burning-out from extreme overload than to lose a considerable percentage of the revenue from long-sustained light loads. This light-load loss can also be obviated by putting the lamps most frequently in use on a separate circuit with a meter to itself.

The increase in the "friction-load" of the meter during use, which impairs the accuracy of the meter at light loads, is very fully discussed. The three chief factors influencing this are:—(1) The point of installation; (2) adjustment; (3) the accumulation of dirt. As regards (1) vibration should be avoided as much as possible, since it causes deformation of the pivots of the meter arbors and ultimate chipping of the jewels. In cases where this is unavoidable, the meters should be so constructed as to permit the easy renewal of both pivot and jewel. The point of least vibration is generally in or near the ground floor against a brick wall; points exposed to extremes of heat and cold, dust, dampness, fumes, should be avoided, as are kitchens, pantries, and the like by reason of the insects found in such places. As regards (2), the meters should be carefully levelled, since they are calibrated in a level position, and where vibration is unavoidable they should be mounted on sponge-rubber cushions. Meters for use with motors should be on the station side of the controlling switch; this prevents damage to the insulation of the fine wire potential-windings of the meter by expansion and contraction when the current is turned on and off, or by the kick or induction-current on interruption of the circuit. As regards (3), the average meter should be inspected and cleaned from two to three times annually. Dirt or dust should be removed by a pair of bellows; the condition of jewel tested by moving the pivot gently over the surface of the jewel-cup, when it should feel smooth and glass-like; poles of damping magnets, if any, brushed off with a thin piece of magnetised steel; commutator, if any, cleaned with cotton tape. The meters should *not* be oiled, as the merest film lasts for an indefinite period and too much ruins the light-load accuracy of a meter. Meters can be tested *in situ*, roughly, by putting a definite number of lamps on the meter, and determining the speed at which the meter-shaft rotates at this load, say by timing 1, 10, or 100 revolutions by a stop-watch; this method may be taken as being correct within 6 per cent. More correct results can be obtained

by using an ammeter in series with the meter on the load side, with or without a voltmeter across the line on the station side of the meter. Or a definite load can be obtained by using a box containing say 6 calibrated incandescent lamps of various C.P.s, controlled by separate switches, in combination with a portable voltmeter.

The meter-men should only record the dial-indications by marking with a pencil the position of each hand on a printed diagram of the dial, the indications being afterwards translated by a competent person. To equalise the bills in the winter months, the readings may be taken on Nov. 5, Dec. 2, Jan. 1, Jan. 30, Feb. 27. A system of meter cards is also described in the original paper.

In the discussion on the above paper (Amer. Inst. Elect. Engin. 14. pp. 443–450, 1897), **Dr. Louis Bell** spoke mainly on the question of charging for alternating currents supplied to circuits having highly-inductive loads, so as to fairly compensate the supply company for the capacity of the machine used up by the wattless currents at light loads taken by motors having low power-factors. He suggested an ampère-meter acting in conjunction with the watt-meter to automatically take account of the maximum current. In reply to Dr. Perrine, **Mr. Haskins** said that, in his experience, a meter which will give accuracy, both at light load and also at high loads, will almost invariably be a good meter on intermittent loads. **Mr. Haskins**, in reply to Dr. Bell, considered it possible to produce a meter which will automatically vary its rate with the variation of the power factor. **Prof. Owens** suggested that this might be done by the addition of a "Wright-Demand" meter to the circuit containing a watt-meter. Mr. Haskins said that this would be imperfect in that it did not segregate idle from active currents, although it would otherwise be admirable. **Mr. Steinmetz** suggested that a part of the wattless currents could be charged for by replacing part of the non-inductive resistance of the potential coil of a recording watt-meter by reactance, say equal to 20 per cent. of the impedance of the potential coil, reducing the resistance correspondingly. With this the meter would read correctly at non-inductive load, but with a highly inductive load, of 20 per cent. power-factor or so—as the current of a motor running light—the meter will read just twice the power, or about one quarter of the wattless current. Mr. Steinmetz also pointed out the fact that some kinds of load, such as fan-motors and apparatus of high frequency for producing X-rays, broke up or changed the character of the current-wave so that it will pass through current-meters without being registered. This fact was confirmed by Mr. Haskins.

C. K. F.

TELEGRAPHY AND TELEPHONY.

228. *Wireless Telegraphy.* **E. J. Houston** and **A. E. Kennelly.** (Elect. World, 31. pp. 17–18, 1898.)—This compilation is a short description of the various systems of Hertzian telegraphy.
R. A.

229. *Efficiency of Telephone Translators.* **L. Lefèvre.** (Ind. Élect. 7. pp. 11–14, 1898.)—The ratio of the watts supplied to the primary of a telephone translator to the corresponding watts in the secondary, is a measure of the efficiency of that instrument. This ratio has been determined by A. Reding for six kinds of translators, at different frequencies. Special attention is given to the material and form of the iron core. The required ratio is measured by two electro-dynamometers, one in the primary and the other in the secondary circuit. Current is supplied to the primary by an alternator at a frequency of 75 to 750, it does not exceed 8 milliamperes. The resistance in the secondary is varied from 0 to about 6000 ohms. A table gives the power lost in heat and the power lost in hysteresis for each case; a curve shows the efficiencies at different frequencies; and a figure gives the arrangement of apparatus. In order to reproduce, so far as possible, the actual case of an inter-urban telephone trunk-line system, Reding builds up an artificial circuit containing capacity and self-induction.
R. A.

230. *Telephone Tariff.* **X.** (Électricien, 14. pp. 389–390, 1897.)—An equable scale of charges between telephone companies and subscribers may be based either upon the number of "calls" per annum, or upon the total time that the subscriber is in circuit during the year. Theoretically, the scale ought also to be modified in a manner depending upon whether a "call" is to a subscriber in the same or in a different district. The working expenses of the company depend upon the number and duration of the "calls," and upon the number of distinct offices through which communication has to be established for a particular "call." If the subscribers are on different "exchanges" the switching operations occupy time and require an increased staff. The writer discusses the method of charging by annual tax supplemented by the number and duration of calls. Practically, the dual system of tariff leads to complication; choice has to be made between a tax founded upon the number of "calls" and a tax proportional to the time. Preference is given to a tariff based upon the number of "calls."
R. A.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MARCH 1898.

GENERAL PHYSICS.

231. *Automatic Mercury Pump.* **F. Friedrichs.** (Annal. Phys. Chem. 62. pp. 383–384, 1897.)—This is Kahlbaum's modification of the Sprengel pump provided with an apparatus for automatically cleaning and drying the mercury in its passage.

E. E. F.

232. *Surface Tension.* **N. E. Dorsey.** (Phys. Rev. 5. pp. 213–230, 1897.)—This paper is a continuation of an earlier one (see Phys. Soc. Abstracts, No. 688, Dec. 1897). The surface-tension of water at 18° C. is 73·32 dynes per cm. The surface-tension of certain *dilute* solutions is given by the formula $T_s = T_w + KC$, where T_s is the surface-tension of water containing c gram-equivalents per litre, T_w is the surface-tension of water at the same temperature, and K is a constant. At 18° C., for NaCl, KCl, $\frac{1}{2}(Na_2CO_3)$, $\frac{1}{2}(K_2CO_3)$, and $\frac{1}{2}(ZnSO_4)$, K equals 1·53, 1·71, 2·00, 1·77, and 1·86 respectively.

A. Gs.

233. *Measurement of Air-films.* **C. Fabry** and **A. Perot.** (Annal. Chim. Phys. 12. pp. 459–501, 1897).—The necessity for the measurement of thin air-films was introduced in connection with experiments by the authors on electrometers in which the distance between two surfaces had to be obtained. The present paper describes the method adopted, and also contains a general consideration of the interference fringes produced when light passes through a thin air-film between two semi-silvered glass surfaces. The silvering of the glass increases the reflecting power of the surfaces, and makes the fringes much sharper and narrower than is the case when ordinary glass surfaces are used. If the

air-film is not of uniform thickness and a beam of monochromatic light be sent through it, then wherever the thickness of the film is a multiple of the wave-length a bright band is observed, the form of the bands depending on the shape of the surfaces. If the light is not monochromatic, then coloured bands are observed; and if the air-film is wedge-shaped in form with perfectly plane sides, the bands are parallel and equally spaced, the thickness of the film increasing by one wave-length between two successive bands of the same colour. It is evident that if the thickness of the film in wave-lengths could be determined at any one point of such a prism, then at any other point it would also be known in terms of the same wave-length.

When the light used contains only two wave-lengths, two systems of bands are produced which coincide the one with the other at regular intervals, the intervals being smaller the greater the difference between the wave-lengths. By employing such light an easy means of counting the fringes is provided. When two films are superposed by placing one behind the other, or, better, by placing one at the optical image of the other by means of a lens, and a beam of parallel white light is sent normally through them, then, wherever the thicknesses of the two films are equal or bear a simple ratio to each other, Brewster's white bands are observed, the intensity of the band being greatest for equality of thickness, and decreasing as the ratio of the thicknesses becomes less simple. Between these white bands coloured interference-bands are observed, due to difference of thickness of the two films.

To find the thickness of any thin film of air, it is sufficient to superpose it optically on a standard wedge-shaped film and find by means of the bands in white light where the thicknesses of the two are equal.

This standard can be made of two lightly silvered strips of glass placed face to face with pieces of tin-foil of different thicknesses between the ends, a mm. scale being engraved along one of the strips. The interference-fringes observed when the standard is viewed in sodium light enable one to calibrate the mm. scale in wave-lengths of this light, provided the thickness of the film is known at one point. To obtain this, let us suppose the film varies in thickness from about 100 wave-lengths at the one end to 300 at the other. Make another film approximately about 120 wave-lengths in thickness; then, by superposing this on the standard, find the points where the latter has the same and also double the thickness of the former. Knowing the number of sodium bands which occur between these two points on the standard, one obtains at once the thickness of the standard film at the first point. J. B. H.

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234. *Protection of Instruments from Vibration.* **A. Broca.** (Écl. Électr. 13. pp. 581–583, 1897.)—The author points out that in the case of instruments such as galvanometers in which

the movable parts are very light, no advantage is obtained by supporting the instrument on rubber blocks, but that in this case the instrument ought to be suspended by strings. With instruments in which the part which has to be preserved from tremors is massive, on the other hand, rubber blocks are of use. W. W.

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235. *The Distribution of Mass in the Earth.* **E. Wiechert.** (Göttingen Nachrichten, 3. pp. 221–243, 1897.)—As the mean density of the earth is about 5·6, that of the materials of the surface averaging 3, and as the substances of greater density than 5·6 are almost all metals, Wiechert assumes that the earth has a metallic interior and that the change in density will be abrupt. To simplify his calculations, he supposes that the metallic core has one uniform density, and the shell another. He starts from the hypothesis of hydrostatic equilibrium, that core and shell would be limited by gravitational levels. Various considerations lead him to assign a density of 7·8, that of compressed iron, to the metallic core. As the pendulum on the whole is little influenced by the relief of the surface, and as layers, several kilometres in thickness, have been transposed in the course of time, he further accepts the supposition that the surface-crust is borne by a layer of materials in the fused state. That layer cannot be thick because earthquake waves appear to be propagated along the surface, and the earth as a whole behaves, as regards the tides, like a body with the rigidity of steel. In round numbers the core would have a radius of 5000 km., the shell a radius of 1400 km. (between 1200 and 1600 km.): the shell and core would be about equal in volume, and the ratio of their masses would be 2 : 5. The geoid seems to deviate little from an ellipsoid. Whether or not there be hydrostatic equilibrium is investigated by comparing the values for the aplanatism of the earth as deduced from geodetic measurements, variations of g, and disturbances of the moon's orbit, with those deduced from nutation and precession. The comparison seems to indicate that the core is slightly less flattened than would correspond to the present velocity of rotation. H. B.

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236. *Velocity of Outflow of Gases and Steam.* **H. Parenty.** (Annal. Chim. Phys. 8. pp. 1–79, 1896, and 12. pp. 289–37?, 1897.)—These two papers contain an account of the author's work during the last twelve years, on the outflow of gases through orifices of different shapes. The subject was left by Hirn in an unsatisfactory state, as his experimental data went beyond the theory that existed to account for them. Parenty has succeeded in giving a satisfactory reduction of Hirn's experiments, and has added new data of his own. The elementary theory assumes that when a gas flows out through a narrow orifice from a chamber of higher to one of lower pressure, that the phenomenon is

adiabatic. This leads to the conclusion that the velocity of outflow

$$U = \sqrt{2gECT_0(1-\rho_1{}^\gamma)},$$

where E = dynamical equivalent; C = specific heat at constant pressure; T_0=absolute temperature of the gas in the reservoir; $\rho_1 = p_1/p_0$, where p_0 is the pressure in the reservoir, p_1 the (variable) pressure at the point considered: $\gamma = 1 - c/C$, where c=specific heat at constant volume. The pressures are given in gravity units (tons per sq. m.). The volume of outflow, expressed in terms of the density of the reservoir, is

$$V_0 = m_0 m_1 S \rho_1{}^{1-\gamma} U_1,$$

where S is the cross section of the orifices, and $m_0\, m_1$ numerical coefficients, so that $m_0 m_1 S$ is the area of the so-called *vena contracta.*

The result of experiments can be expressed by means of this formula, but with considerable variation in the coefficients $m_0\, m_1$ according to the pressures: provided ρ_1 does not fall below a certain value. But if the pressure in the recipient falls to a certain fraction of p_0, the velocity of the gas at the neck of the stream (which may be in front or behind the actual orifice) rises to that of sound in gas at the temperatnre of the neck. The fraction (a function of the specific heats) is 0·526 for most gases. Below this no reduction of pressure in the receiver makes any difference to the velocity of outflow, which has reached its limit.

Parenty finds that the observations on the volume of outflow can be more satisfactorily represented by an elliptic formula

$$V_0 = \sqrt{2a}\, m_1 S \sqrt{2gE(C-c)T_0} \sqrt{R_1 - mR_1{}^2/2a},$$

where $R_1 = 1 - \rho_1 = 1 - p_1/p_0$, $a = 0·474$=limiting value of R_1 (as above), whilst m_1, the only arbitrary quantity remaining in the equation, is practically the same as the observed coefficient of contraction for liquid jets flowing from the same orifice. If the results are expressed graphically, taking R for abscissa and V_0 for ordinate, the curve is a quadrant of ellipse starting from the origin, with major axis vertical, and situate at $R_1 = a$; beyond that value of R_1 the curve is continued by its (horizontal) tangent. The corresponding curve of velocities in the neck is a sinusoid starting from the origin concave to the axis of x and reaching a point of inflexion for $R_1 = a$, where the velocity becomes equal to that of sound.

Beyond the neck the jet spreads out again, and the gas possesses a velocity which for some distance is sensibly equal to that at the neck. The distribution of pressure and velocity in this section of the jet was the subject of special experiments, described in the second of the two papers. For this purpose the jet was "sounded" by means of glass tubes, drawn out to a point at one end, the other being connected to a manometer. The tubes were mounted on a sort of slide-rest, which allowed of their being

placed at a measured distance in front of an orifice fed by a steam-boiler, either in the axis of the jet or to one side of it. Three tubes were used, one pointing directly at the jet, the second with the point turned round 180°, the third with the point at 90° from the stem. By means of these the apparent pressure, both backwards and forwards, in the direction of the axis, and in both senses of a direction perpendicular to the axis, could be measured; the mean giving the actual pressure, apart from the effects of molar velocity, at each point. The results obtained for two orifices—one convergent, the other so-called contracted—are shown by means of diagrams of the kind used in topography.

The results are complicated; some of the most interesting points being as follows:—At a distance of about two diameters from the orifice the pressure is observed to have the value corresponding to $R_1 = a$, *i. e.* the limiting value below which a reduction in the pressure of the receiver has no effect in increasing the rate of flow. Beyond this point occurs a loop of pressure, followed by other nodes and loops: three of each could be distinguished, strongly marked, when the pressure in the receiver (*i. e.* the atmosphere) was much below the limiting pressure; but as that value was approached, the nodes and loops became much reduced in magnitude, though more numerous, till, when the pressure in the neck was but little in excess of that in the atmosphere beyond, they disappeared altogether. The neck of limiting pressure formed in the case of the convergent orifice (cone of 15°—the most favourable form) coincided in position with the summit of the cone; at that point the stream of gas possesses a "wave-front" convex towards the orifice, and presenting a close analogy to the *vena contracta* of a liquid jet.

The author makes an ingenious, though somewhat vague comparison between the behaviour of a jet of gas and the rupture of a solid bar. The peculiarity of the jet lies in the fact that, when the pressure of the receiver is below the limiting value, the two portions before and behind the neck are absolutely independent of one another: the distribution of pressure in the expanding jet beyond the neck may vary in any manner without influencing the flow in the contracting portion in any way; so that the jet is, as it were, broken in two. There is, moreover, an analogy of mathematical conditions to be drawn between the solid and gas, since a solid bar may be broken by projecting a section of it with an impulsive velocity $> U_s\Delta$, where U_s is the velocity of sound in the material, and Δ the maximum strain it will stand, whilst the conditions at the neck of the jet can be expressed in a similar way.

It is incorrect to suppose that the contracted area mS of the jet represents any real section of it. On the contrary, the jet spreads out laterally immediately on escaping from the orifice, and the jet from apertures called "contracted" (such as openings in a thin plate) spreads out more than that from a convergent orifice. The apparent contraction of area is due to the divergent angles of the stream lines which meet at the orifice, and is only indefinitely

represented by the section of maximum velocity previously referred to, and also by the subsequent maxima, which by a sort of rebound of the gradually expanding jet form a set of images of the first.

Experiments on the temperature of the jet before and after passing the orifice are also described; they were made on a steam-jet, to supplement the observations of Hirn, who measured the pressures only: and were found to give results in general accord with the author's theory.

Besides theoretical conclusions, the first of the two memoirs contains a collection of formulæ on the volume of outflow, and the time required to empty or fill a reservoir, which will be of practical service to engineers; and a description of an instrument, which, placed in the path of a steam-pipe, shows on a direct-reading scale the rate of flow of the steam at any moment. R. A. L.

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237. *Viscosity of Bromine.* **L. Kann.** (Berlin. Akad. Sitzber. 106. pp. 431–435, 1897.)—The coefficient of viscosity of bromine determined by the time of passage along a tube equals 0·014268 at 0° C.; 0·013584 at 5°; 0·012955 at 10°; 0·012363 at 15°; 0·011829 at 20°; 0·011327 at 25°; 0·010874 at 30°; 0·010469 at 35°; 0·010114 at 40°; 0·009793 at 45°; and 0·009489 at 50°. A. Gs.

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238. *Measurement of Small Displacements.* **A. Righi.** (N. Cimento, 6. pp. 349–352, 1897.)—The author describes a simple method of measuring small displacements, such as the motion of a point on an expanding bar. It consists essentially of a short lever supported at two close points on the same side of its centre of gravity by two very fine stretched fibres, one of which runs in an upward direction, and the other downward. The directions of the fibres will intersect on the vertical through the centre of gravity of the lever. The lower end of the lower fibre is fixed, and the upper end of the upper one is attached to the moving point. When the point moves upward or downward, the lever is tilted, and the angle of tilt is measured by a telescope, or lamp, and scale. In the actual instrument the suspension is bifilar; a thread of three cocoon-fibres is formed into a rectangle, the two upper corners of which are fastened to a rod connected with the moving point, and the two lower corners to a similar rod connected with the fixed point. The thread passes between two jaws at each end of a crosspiece attached horizontally at right angles to the lever. By this means errors due to torsion of the fibre are avoided; and by using short fibres changes in length due to humidity of the air do not cause any appreciable error. The author has succeeded in magnifying a small motion twenty thousand fold by this apparatus. J. L. H.

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239. *Hydrometer.* **Vandevyver.** (Journ. Phys. Chem. Élem. 13. pp. 24–26, 1897.)—This is a hydrometer with a thin stem and long cylindrical bulb divided by a diaphragm into two parts, an upper and a lower. The upper contains air, and the lower, which is closed by a stopper, is filled with the liquid whose specific gravity has to be determined. The hydrometer is then floated in water, and the specific gravity read off on the stem which is previously calibrated. J. B. H.

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240. *Physical Pendulum.* **J. S. Stevens.** (Amer. Journ. Sci. 5. p. 14, 1898.)—In determining g by the common form of physical pendulum, error is introduced by the fact that the knife-edges and clamp affect the moment of inertia and centre of gravity of the pendulum. The author avoids this by boring a hole through a brass cylindrical rod about 8 cms. from one end. The knife-edges are screwed a little way into the hole, one on each side, and their mass adjusted so that they compensate for the mass of brass bored out. The centre of gravity of the system remains that of the original bar. The source of error would be entirely removed if the centre of oscillation of the triangular knife-edges were in the same horizontal plane as that of the removed cylinder. If the radius of this cylinder be r, the distance from the centre of oscillation to the point of suspension is, in the case of the triangle $\frac{5}{4}r$, and in the case of the cylinder $\frac{3}{2}r$. Allowing for the relative densities of steel and brass, the knife-edges may be so constructed and inserted that this result may be brought about. If, however, this error be neglected, the effect will be a raising of the centre of oscillation, in the region from which the brass has been removed, of $\frac{1}{4}r$. E. C. R.

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241. *Harmonic Analyser.* **A. A. Michelson** and **S. W. Stratton.** (Amer. Journ. Sci. 5. pp. 1–13, 1898.)—This is a machine for obtaining graphically the resultant of a number of simple harmonic motions, by means of the addition of forces of spiral springs. A lever in the form of a cylinder pivoted on its axis has attached to one side of it 80 small springs placed side by side; to the other side of the cylinder is a large spring parallel to the small ones, and of sufficient strength to counterpoise their force. The end of each small spring not attached to the cylinder is fixed to the end of a lever, to which a simple harmonic motion is given by means of an eccentric, the motion being conveyed to the lever by a rod which receives its motion from a rocking-lever worked by the eccentric; by sliding the rod along the rocking-lever, the amount of motion given to the end of the spring, or the amplitude of the term in the Fourier series represented by that spring, can be adjusted. The resultant motion of the cylinder is recorded by a pen, connected with a lever attached to the cylinder by a fine wire. Under the pen moves a slide with a speed proportional to the angular motion of a cone driving the eccentrics. To represent the succession of terms of a Fourier

series, the eccentrics have periods increasing in regular succession from 1 to 80. This is accomplished by gearing to each eccentric a wheel the number of whose teeth is in the proper ratio. These wheels are all fastened together in the same axis, and form the cone before referred to. The machine is capable not only of summing up any given trigonometrical series, but can also perform the inverse process of finding for any given function the coefficients of the corresponding Fourier series. The paper is illustrated with many specimens of curves obtained by use of the machine. E. C. R.

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242. *Deformation of Metals.* **M. Brillouin.** (Comptes Rendus, 126. pp. 328–330, 1898.)—This is a note on a theoretical investigation of the properties of commercial metals, which will appear shortly in the 'Journal de Physique.' The author considers the commercial metals as heterogeneous structures built up of elastic crystals to which the laws of elasticity apply, and between the crystals a viscous cement of metal which obeys the laws of viscosity. Considering the effect of stress on such a mass, he is able to explain all the phenomena connected with stresses in metals, such as time lag, hysteresis, permanent set, etc. J. B. H.

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243. *Apparent Exceptions to Hooke's Law.* **M. Brillouin.** (Annal. Chim. Phys. 13. pp. 231–260, 1898.)—This paper contains a discussion of cases in which there appears to be a departure from Hooke's Law, due, however, only to variability in the constraints of an elastic system. Certain general theorems are given, and particular cases discussed by Hertz (Crelle's Journ. 1882) are examined in further detail. When an elastic body is maintained in equilibrium by forces applied over a surface (*e. g.* a bar held by screw clamps), if a change of stress causes the area over which the forces are applied (*i. e.* area of contact of the clamps) to change, then the strain will not in general be proportional to the stress, even for infinitesimal strains, although Hooke's law remains true. The first case considered in detail is that of Auerbach's method of testing hardness (Wiedem. Ann. 43. p. 88), in which a spherical point is pressed on a flat plate till rupture occurs. The author considers that his theory accounts satisfactorily for the observed phenomena, and that the fracture depends not on the ordinary elastic properties of the substance, but on a superficial elasticity, which therefore is suitable for defining the "hardness" of the mineralogists. The knife-edges of pendulums used in geodetic survey are, according to the author, insufficiently strong for the weight they usually carry, so that they penetrate to some extent into the agate planes, and the pendulum acquires a rolling motion which introduces a quasi-viscous resistance and an inaccuracy in the determination of gravity; lighter pendulums should be used. A chain composed of equal links of circular section is a case easily worked out, in which the elongation is not proportional

to the load. Levelling screws with round points give way to an extent proportional to the $\frac{2}{3}$ power of the load on them. Care should be taken that the centre of gravity of an instrument remains rigorously fixed for all the movements that the instrument may have to make: thus a telescope may very well be shifted through half a second by the giving of the supports, in case the load is unequally placed. Supports resting on a hole-slot and plane necessarily give to an unequal extent. R. A. L.

LIGHT.

244. *Solar Light.* **A.** and **A. Garbasso.** (N. Cimento, 6. pp. 313–321, 1897.)—The researches of Langley with the bolometer have furnished curves showing the intensity of the light of each wave-length in the solar spectrum. From these curves the amplitude of each single vibration can be found, this being proportional to the square root of the corresponding intensity. The separate vibrations are all superposed on the medium transmitting the light, so that the resultant motion of the medium is the algebraic sum of the separate vibrations, the number of which is infinite. The authors have taken from Langley's curve the ordinates corresponding to wave-lengths at equal small distances apart, and by assuming all vibrations to be in the same phase have determined numerically the motion resulting from their superposition. It proves to be a highly damped periodic motion, the wave-length of which is about 0·00017 cm., and therefore large in comparison with the wave-length of the brightest portions of the spectrum (0·00006 cm.). The logarithmic decrement of the vibration appears to be about 3·3. J. L. H.

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245. *Transformation of Röntgen Rays by Metals.* **G. Sagnac.** (Comptes Rendus, 125. pp. 942–944, 1897.)—There is no appreciable regular reflection from metals even from the surface of mercury at an angle of 75°. The secondary rays emitted by the metal under these circumstances pass some centimetres through the air. They are sharply bounded by the plane of the metallic surface, and therefore travel in straight lines without diffraction. The position of this sharp boundary is not affected by a prism of paraffin, and therefore there is no refraction; they are not regularly reflected by a metallic surface, but are diffused just like the original Röntgen rays. They traverse aluminium; they discharge electrified bodies, and this explains the action of metals in the discharge of conductors directly impinged upon by Röntgen radiations: coming from different metals they have different penetrative powers. They differ from Röntgen rays in being less fully transmitted through various substances, such as metals, glass, mica, paraffin, black paper, air; and even aluminium transmits them feebly, but it diffuses them and makes them undergo another transformation. These secondary radiations from metals seem to bear the same relation to the original Röntgen rays, as the rays emitted during luminescence do to the impinging rays. Aluminium does not produce these secondary rays. A. D.

246. *Discharge of Conductors under Röntgen Rays.* **G. Sagnac.** (Comptes Rendus, 126. pp. 36–40, 1898.)—The following phenomena are not explained by M. Perrin's views as to gas effect and metal effect. The surface of a metal, impinged upon by Röntgen rays, gives off new rays ("secondary radiations of the metal M") which are much more absorbed than Röntgen rays; they do not traverse the soft parts of the human hand, but they discharge conductors after the manner of Röntgen rays, apparently not by meeting them or the lines of force, but by making the air electrically conductive. The photographic effect of these secondary rays falls off rapidly with increase of distance; and black paper shields the plate somewhat when these rays come from copper, more when from zinc, and specially when from tin or lead. The secondary rays are absorbed by a thickness of the same metal as has given rise to them, about one-hundredth of the thickness which would be necessary in the case of Röntgen rays; and this explains M. Perrin's having found that the metal-effect per unit of surface is independent of the inclination. The effect of metal cannot be explained by superficial ionisation, because it is manifest at a distance; it rather appears that the air is rendered conductive both by the Röntgen rays and by the secondary metal-rays. A. D.

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247. *Photographic Negatives from Printing Blocks, etc.* **A. Guébhard.** (Comptes Rendus, 126. pp. 40–43, 1898.)—If a plate, very slightly fogged, be pressed against a printing-block well cleaned, with the developer filling the hollows of the block, and the whole left to itself, the developer will act along the hollows and not along the ridges, and make a negative from which a reversed positive can be made. If a coin be treated in the same way, the varying thicknesses of developing solution produce corresponding amounts of reduction, so that the negative gives the coin in relief, but with markings due to capillary forces. A. D.

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248. *Change of Phase through Metallic Reflection.* **H. Kath.** (Annal. Phys. Chem. 62. pp. 328–352, 1897.)—The experiments were made with absolutely pure metallic mirrors obtained by placing glass plates next kathodes of silver or gold in a vacuum-tube. An even deposit on the glass was produced by the disintegration of the kathode in an atmosphere of hydrogen. It was found that the change of phase is an acceleration in the case of silver and gold, amounting to $0{\cdot}55\,\lambda$ in the case of silver in air, and to about $0{\cdot}25\,\lambda$ in the case of gold in air. The acceleration is independent of the incidence in the case of silver, but in the case of gold it increases to $0{\cdot}5\,\lambda$ at grazing incidence. For platinum the acceleration is $0{\cdot}39\,\lambda$. E. E. F.

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249. *Measurement of Refractive Index.* **M. G. Weiss.** (Journal de Physique, 6. pp. 688–690, 1897.)—The author extends

the definition of the "power" of an optical system to the case where the initial and final media are different by calling n/f the power, where n is the index of the final medium, and f the focal length of the system; this has the same value whichever way the light traverses the system. To measure this power p, an object of length O is placed in the first focus, which gives an image at infinity; this image is viewed by an astronomical telescope, and an image of length I is formed in the focal plane of the object-glass. O and I are easily seen to be connected by the relation $p/p' = \mathrm{I}/\mathrm{O}$, where p' is the power of the object-glass. If O be kept the same, then a scale to measure I can be devised which shall give the power p required at one reading; but the most delicate method is to measure I by means of a cross wire in the focal plane moved by a micrometer-screw. When the initial and final media are different, these can be bounded by plane surfaces which do not alter the focal lengths or the power. The index of a lens can be found by plunging it into two media in turn and measuring the two powers; if n is the index required, n', n'' the indices of the two liquids, and p', p'' the powers found, then $n = n''p' - n'p''/p' - p''$; the most convenient media are air and distilled water. To measure the index of a liquid, a drop of it is placed between two plane convex lenses with their convex surfaces turned towards each other, and the power of the system is measured; we get

$$p = (n - n')\left(\frac{1}{\mathrm{R}} - \frac{1}{\mathrm{R}'}\right),$$

n being the index of the liquid, n' that of the glass; R, R′ the radii of the surfaces. Hence $n = n' - \mathrm{A}p$; the constant A can be found once for all by making an experiment with distilled water.

R. S. C.

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250. *Newton's Rings in Turbid Media.* **J. Stark.** (Annal. Phys. Chem. 62. pp. 368–373, 1897.)—The author deals with the rings seen in a plate of glass with a very slight layer of lampblack, obtained by slightly smoking the plate. The lampblack is in reality a layer of precipitated stearine containing finely divided particles of soot. Hence the layer forms a turbid medium. The rings observed are in reality diffusion-rings. They are well seen when the smoke is deposited on a metal plate. In all cases, the red is very feeble, and looks brownish. This is due to the fact that the medium diffuses the longer waves less than the shorter ones.

E. E. F.

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251. *Apparatus illustrating the Rainbow.* **S. Marcucci.** (N. Cimento, 6. pp. 325–331, 1897.)—The author has previously described an arrangement of jointed rods which serves to determine the direction of a ray of light refracted at a spherical surface. He now shows how it may be applied to illustrate the conditions of minimum deviation when a ray passes into a refracting sphere, suffers one or two internal reflexions, and emerges again. J. L. H.

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252. *Simple Demonstration of the Zeeman Effect.* **W. König.** (Annal. Phys. Chem. 63. pp. 268–272, 1897.)—Two sodium flames are observed in the same line of vision, the farther one being placed in a magnetic field which can be established at will. The flames are viewed at right angles to the lines of force through a dichroiscope or a simple doubly-refracting prism, which gives two images of them. The emission flame being colourless to begin with, only one of the two images brightens up on making the field, that being the one whose vibrations take place in a vertical direction. If the emission-flame is in addition coloured by another salt, a very perceptible dichroism of the two images is obtained.

E. E. F

HEAT.

253. *The Law of Mixture of Gases.* **P. Sacerdote.** (Comptes Rendus, 126. pp. 338–340, 1898.)—When Berthollet's experiment, in which equal volumes of two different gases at the same temperature and pressure are allowed to diffuse into each other without change of the temperature and total volume, is repeated with all available accuracy, the pressure is found to increase, but only slightly. Thus with N_2O and CO_2 under 75·940 cm. of mercury a rise of ·008 cm. was observed, which may be ascribed to errors of experiment; and with SO_2 and CO_2 under 76·569 cm. the rise is 1·36 cm. But the rise, as calculated from the assumption of Dalton's law of partial pressures, together with the experimentally determined deviations of the gases from Boyle's law, is considerably greater. Hence Dalton's law of partial pressures is less exact than the alternative form of it, viz.: *the volume occupied by a mixture of gases is equal to the sum of the volumes of the separate gases when at the pressure and temperature of the mixture.* R. E. B.

254. *The Mixture of Gases.* **A. Leduc.** (Comptes Rendus, 126. pp. 218–220, 1898.)—Experiments on atmospheric air and with mixtures of N_2O and CO_2 and of CO_2 and SO_2 show, as in the last Abstract, that Dalton's law of partial pressures for mixed gases is not so exact as his law of partial volumes, which Leduc expresses thus:—*in a mixture each gas should be considered as under the pressure of the whole.* He further concludes that when nitrogen and argon are mixed there is a rise of pressure, so that in 10,000 volumes of atmospheric nitrogen there are 9880 volumes of nitrogen and 119 volumes of argon. R. E. B.

255. *The Cooling of a Heterogeneous Bar.* **W. Stekloff.** (Comptes Rendus, 126. pp. 215–218, 1898.)—This is a mathematical discussion of the integration of the equation

$$\partial^2 V/\partial x^2 + \{kp(x) - q(x)\}V = 0$$

for the values given by $b > x > a > 0$, when the condition $\partial V/\partial x = hV$ holds for $x = a$, and the condition $\partial V/\partial x = HV$ for $x = b$; p and q being positive functions, and k, h, H positive constants. It depends on a method given by Poincaré. R. E. B.

256. *Meaning of* PV/T *in Theory of Gases.* **E. Boggio-Lera.** (N. Cimento, 6. pp. 331–333, 1897.)—The author replies to the criticism of Signor Del Lungo (see Abstract No. 35, Jan. 1898), pointing out that he did not assert the equality of the numerical values of PV/T and the mechanical equivalent of heat. He called attention to the fact that if PV be taken as a measure of the dynamical energy of the gas, and T as proportional to its thermal

energy, the ratio of these two quantities is the mechanical equivalent of heat. In other words, the dimensions of PV/T are the same as those of the mechanical equivalent of heat. J. L. H.

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257. *Comparison of Thermometers.* **E. Gumlich** and **K. Scheel.** (Zeitschr. Instrumentenk. 17. pp. 353-355, 1897.)—This is a communication from the Reichsanstalt on a comparison of thermometers of the same glass but of two different types—the one, the rod type, having the scale engraved on the stem; and the other, the enclosed scale type, having the scale on a strip of white glass fastened behind the capillary stem, both stem and scale being enclosed in an outer glass tube attached to the bulb. A number of thermometers were compared, and the results of the comparisons are given in tabular form in the paper. The general conclusion arrived at is that for an accuracy of over 0°·01 only those thermometers of the enclosed scale type should be used which have been compared directly with one of the rod type, or for which the expansion of the scale is known and can be allowed for. J. B. H.

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258. *Ternary Mixtures*, III. **W. D. Bancroft.** (Journ. Phys. Chem. 1. pp. 760-765, 1897.)—If two liquids A and C are partially miscible at a certain temperature t and a third liquid B is miscible with both in all proportions, there exists a series of solutions at this temperature such that clouding (*i. e.* precipitation) will occur on the addition of a drop of either A or B. These may be represented on a triangular diagram by a curve which is the boundary between the regions corresponding to saturated and unsaturated solutions. This curve may be divided into four stretches—xy, yz, zy', $y'x'$, where x, x' are its intersections with the AC line on the A and C sides respectively, and y, y' are the points where it is touched by tangents drawn respectively from the A and C corners; along xy addition of C produces cloudiness but not addition of A; along $x'y'$ addition of A produces cloudiness but not addition of C; along yzy' addition of either A or C will produce cloudiness, but for the part yz the resulting solution will contain more of A than the original solution, while for the part zy' there will be more of C. The general form of this boundary line is found to be

$$(a-s_2c)_n(c-s_1a)/b^{n+1}=k,$$

where a, b, c are the volumes of the liquids A, B, C in a given volume of the solution, s_1 the solubility of C in A and s_2 the solubility of A in C, and n, k are constants which differ for the four stretches. There is not necessarily discontinuity at these points y, z, y', but only one case has as yet been found in which discontinuity is absent. R. E. B.

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259. *Temperature of Wires traversed by a Current.* **M. Sala.** (N. Cimento, 6. pp. 333–336, 1897.)—When a wire of resistance R ohms and surface S sq. cms. is traversed by a steady current of C amperes, the excess of its temperature (θ) above the surrounding medium is given by the equation $0{\cdot}24\ C^2R = KS\theta$, assuming Newton's law of cooling; K is the emissivity of the surface of the wire. The author describes experiments in which the temperature of the wire was measured by its extension, the wire being vertical and of 23 metres length. The results show that K increases with decrease of diameter of the wire, but remains constant for the same wire within somewhat wide limits of temperature. Newton's law of cooling is therefore obeyed, but conduction apparently modifies the values of K. The amount of heat lost varies with the physical and chemical nature of the surface, although the loss is chiefly due to convection by air, the radiation being small. J. L. H.

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260. *Thermodynamic Potential.* **J. D. van der Waals.** (Archives Néerlandaises, 30. p. 137; Journ. de Physique, 6. p. 600, 1897.)—When two phases of a substance coexist in equilibrium, the pressure, temperature, and thermodynamic potential are respectively the same in the two phases at any point of contact. A kinetic explanation of these conditions as regards pressure and temperature has already been given. It is here now shown that the condition of the equality of the thermodynamic potential is the expression of the kinetic condition of the equality of interchange of molecules from each phase to the other. The author applies his method to the consideration of (i) a single substance; (ii) a mixture of two substances. R. E. B.

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261. *The Plait-curve for a Mixture of two Substances.* **J. D. van der Waals.** (Archives Néerlandaises, 30. p. 266.) *The Critical Conditions of a Mixture.* **J. D. van der Waals.** (Archives Néerlandaises, 30. p. 278; Journ. de Physique, 6. p. 601, 1897.)—The plait-curve, or the locus of the points indicating the state of a mixture of two substances when the temperature and pressure are such that the composition and density of the two coexisting phases are the same, is represented by a differential equation from which its singularities and trend can be inferred in cases where certain observations cannot be made. The author finds that there are two remarkable points, of which one is a point of tangency of the plait-curve with the curve of maxima and minima pressures; and his theory is in sensible agreement with Kuenen's experiments on mixtures of N_2O and ethane. He further formulates the conditions of relative steepness of the plait-curve and that of vapour-pressure which the mixture would have if it were not separable into its two elements. R. E. B.

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262. *Theory of Fusion.* **M. Brillouin.** (Annal. Chim. Phys. 13. pp. 264–275, 1898.)—The author insists that the essential feature of fusion is the loss of rigidity, and that too much attention has been paid in considering the subject thermodynamically to the latent heat, which is rather accidental; he considers that "pasty fusion" is change of state unaccompanied by absorption of heat, so that temperature equalisation does not take place of its own accord. He develops a notion of the rigidity becoming *negative* in liquids, and draws an imaginary curve $\mu = 0$ as boundary between possible liquid and solid states, but without sufficiently explaining how the solid properties are to be measured by a single coefficient; and endeavours to indicate the course of isobaric lines on a (v, T) diagram, grouped round a sort of critical point, and by their means to account for the various phenomena of sharp and gradual fusion, undercooling of liquid, etc. The discussion is highly ingenious and suggestive, but is very far in advance of our experimental knowledge. R. A. L.

263. *Theory of Liquids with Unassociated Molecules.* **G. Bakker.** (Journ. de Physique, 6. pp. 577–588, 1897.)—This article contains an account of the author's theory of liquids, and gives nearly the same theorems as have already been published in German (see Phys. Soc. Abstracts, No. 53, Jan. 1895; No. 248, May 1897; and No. 390, July 1897), and numerical data in support of the deduction that the true latent heat of vaporisation is (for the same liquid) proportional to the difference of densities of liquid and vapour. R. A. L.

ELECTRICITY.

264. *Distribution of Electricity and C. Neumann's Problem.* **W. Stekloff.** (Comptes Rendus, 124. pp. 1026–1029, 1897.)—Let S be a closed surface, M, M′ two points on it, $MM' = r$. Let the angles between MM′ and the normals drawn outwards at M and M′ be ϕ, ϕ'; let *ds* be an element of S—$d\nu$, $d\nu'$. Let ρ_0 be any arbitrary function of position on S. Let

$$\frac{dV_0}{d\nu} = \rho_0.$$

Form the series of integrals

$$V_1 = \iint \rho_0 \frac{1}{r} dS, \qquad \frac{dV_1}{d\nu} = \rho_1,$$

$$V_2 = \iint \rho_1 \frac{1}{r} dS, \text{ etc.}$$

Then it can be shown that the greatest and least values of V_2, as it varies from point on S, lie between the greatest and least values of V_1, and so on. So that, continuing the process indefinitely, we come in the limit to $V_\kappa =$ constant. $V_{\kappa-1}$ is the density of the equipotential distribution. By a further application of the same method is obtained the series,

$$V = \frac{1}{2\pi}\int(\lambda\rho_0 + \lambda^2\rho_1 + \ldots + \lambda^{\kappa+1}\rho_\kappa + \text{etc.})\frac{1}{r}\, dS;$$

where λ is positive and less than unity. With $\lambda = 1$, we have the solution of Neumann's problem for the interior space; with $\lambda = -1$, for the exterior space. S. H. B.

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265. *Potential of Opposite Charges on a Surface.* **A. Liapounoff.** (Comptes Rendus, 125. pp. 694–696, 1897.)—If μ be the distance between the two charged surfaces at the point P, the potential at Q, any external point, of an element *ds* of the double surface is

$$W = \frac{\mu \cos\phi ds}{r^2}.$$

And for the whole surface

$$W = \int \frac{\mu \cos\phi ds}{r^2}.$$

This is called the "potentiel d'une double couche."

Let *dn* be an element of the normal to the surface. Then our author says it will be admitted generally that if P and P′ be two points on the surface which are made to approach one another meeting in the point M_0,

$$\lim\left(\frac{dW}{dn}\right)_P = \lim\left(\frac{dW}{dn}\right)_{P'}$$

but this proposition has never yet received strict proof.

First establish the two theorems.—I. Let μ be any continuous function. Suppose that at the point M_0 on the surface the normal sections are all of finite and determinate curvature. Then, if the points P P′ on the surface be made to approach M_0, always maintaining the relation $PM_0 = P'M_0$, we shall have

$$\lim\left(\frac{dW}{dn}\right)_P - \lim\left(\frac{dW}{dn}\right)_{P'} = 0.$$

Theorem II. The preceding conditions for the point M_0 being satisfied, take M_0 for origin and ρ, θ for polar coordinates in the tangent plane at M_0, and assume

$$\frac{1}{2\pi}\int_0^{2\pi}\mu d\theta = \bar{\mu}.$$

Then if α be any positive number such that

$$\lim_{\rho=0}\left(\frac{\bar{\mu}-\mu_0}{\rho^{1+\alpha}}\right) = 0,$$

μ_0 being the value of μ at M_0, we shall have determinate limits for

$$\left(\frac{dW}{dn}\right)_P \quad \text{and} \quad \left(\frac{dW}{dn}\right)_{P'},$$

and these limits are equal. The complete analysis is promised in a future communication. S. H. B.

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266. *Capacity of an Anchor-ring Condenser.* **N. Boulgakoff.** (Écl. Électr. 14. pp. 67–69, 1897.)—Having in his former papers (see Phys. Soc. Abstracts, No. 620, Oct. 1897, and No. 707, Dec. 1897) obtained the capacity of a conductor in the form of a ring, M. Boulgakoff now proceeds to the problem of the capacity of a condenser of the same form. The equation to the two surfaces forming the ring shall be $\lambda=c_1$, $\lambda=c_2$, λ being the peripolar coordinate defined in the former papers.

The potential at any point between the surfaces is

$$R\Sigma\left(M_n J_n^0(\lambda)+N_n A_n^0(\lambda)\right)\cos n\omega \quad . \quad . \quad . \quad . \quad (3)$$

in the notation of the former papers, that is

$$R = \sqrt{1-2\lambda\cos\omega+\lambda^2},$$

$$J_n^0(\lambda) = \frac{1}{2\pi}\int^{2\pi}\frac{\cos n\omega\, d\omega}{\sqrt{1-2\lambda\cos\omega+\lambda^2}},$$

$$A_n^0(\lambda) = \frac{\lambda^n}{2\pi}\int_0^{2\pi} \frac{d\partial}{\left(\lambda^2 \cos^2\frac{\partial}{2} + \sin^2\frac{\partial}{2}\right)^{\frac{2n+1}{2}}}.$$

V_1 is the potential of the interior ring-surface, V_2 that of the exterior. Since for $\lambda = c_1$ the expression (3) is V_1, and for $\lambda = c_2$, V_2,

$$M_n J_n^0(c_1) + N_n A_n^0(c_1) = 2V_1 J_n^0(c_1)$$

$$M_n J_n^0(c_2) + N_n A_n^0(c_2) = 2V_2 J_n^0(c_2), \text{ where } n > 0,$$

$$M_0 J_0^0(c_1) + N_0 A_0^0(c_1) = V_1 J_0^0(c_1)$$

$$M_0 J_0^0(c_2) + N_0 A_0^0(c_2) = V_2 J_0^0(c_2);$$

whence in the notation of the former papers,

$$N_n\left(\frac{1}{k_n c_1} - \frac{1}{k_n c_2}\right) = V_1 - V_2.$$

Then by the usual relation

$$-4\pi e_1 = \frac{dV}{d\nu} + \frac{dV'}{d\nu}$$

he obtains

$$-4\pi e_1 = -\frac{R_1^{\,3}}{2a}\,\frac{2\sum_{n=0}^{n=\infty}\frac{Nn}{J_n^0(c_1)}\cos n\omega,}{\pi c_1(1-c_1^{\,2})}$$

R_1 being $\sqrt{1-2c_1\cos\omega + c_1^{\,2}}$.

An element of surface is, as before shown,

$$dS = \frac{2a^2 c_1(1-c_1^{\,2})\,d\omega\,d\phi}{(1-2c_1\cos\omega + c_1^{\,2})^2}.$$

If $E = \int e\,dS$,

$$E = \frac{a}{2\pi^2}\int_0^{2\pi} d\phi \int_0^{2\pi} \frac{N_n}{J_n^0(c_1)} \cos n\omega \frac{1}{R}\, d\omega;$$

also

$$E = 2a\Sigma N_n = 2a\Sigma \frac{V_1 - V_2}{\frac{1}{k_n(c_1)} - \frac{1}{k_n(c_2)}}.$$

The capacity required is

$$\frac{E}{V_1 - V_2}\sum_{n=0}^{n=\infty} \frac{1}{\frac{1}{k_n(c_1)} - \frac{1}{k_n(c_2)}}.$$

S. H. B.

267. *Motion of a Charged Body.* **O. Heaviside.** (Electn. 40. pp. 379–380, 1898.)—This is a criticism of the statement, made at different times by several physicists, that a charged body cannot move at a greater speed than that of light, because at this speed the energy of the charge is infinite, and an infinite amount of work must therefore be done on the charged body: it must experience an infinite resistance. The author points out that the fallacy arises from the assumption that a disturbance of electric displacement travels with infinite speed. If it be assumed to travel with the speed of light, a charged body moving with this speed will not disturb the ether in front of itself, but will experience a pull-back requiring expenditure of energy to keep up its speed. Again, if a positive charge and an equal negative one be moved together with the speed of light, the energy required is finite whatever be the velocity of propagation of polarisation in the ether; so that, according to the usual assumption of infinite velocity, two opposite charges might move together at the speed of light, but they could not be moved separately at this speed.

J. L. H.

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268. *Resistance and Self-Induction.* **J. Schurr.** (Journ. de Physique, 6. pp. 588–592, 1897.)—Certain theorems are given on the geometrical relations between the resistance and self-induction of a pair of conductors immersed in an infinite medium, showing how a knowledge of the one will enable the other to be calculated, in terms of the assumed permeability and conductivity of the medium. The article hardly admits of an abstract. R. A. L.

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269. *Electrification of Air.* **E. Warburg.** (Annal. Phys. Chem. 63. pp. 411–418, 1897.)—A needle was mounted in a tube as an electrode, and was surrounded by a net of wire gauze serving for another electrode. The tube was provided with a cross tube through which a current of air was blown, which traversed two holes in the wire gauze and eventually entered a brass tube with a cotton-wool plug enclosed in a wire net, the brass tube being connected with an electrometer which indicated any electrification of the emerging air-current. Such electrification is indicated at first, but as the dust is eliminated it gradually falls to nearly zero. When the air is dry, some needle-points apparently electrify it. But since such electrification is stopped on closing the holes in the wire net, it is evident that the charge must be conveyed by particles large enough to be stopped by the meshes. Experiments showed that ultra-violet light had no effect on the discharge. If the air is blown past a platinum wire rendered incandescent by a current, a charge is observed which is due to the disintegration of the wire. In hydrogen no disintegration takes place, and no electrification is observed.

When a current of moist air is sent through the apparatus, an apparent electrification is obtained. But this disappears on

warming the air-current, so that it is probably due to condensed water particles. All the results therefore speak against the direct electrification of a gas. E. E. F.

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270. *Magnetic Survey of Sicily.* **L. Palazzo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 331–337, 1897.)—This paper contains a short abstract of the results the author has obtained when carrying out a magnetic survey in the island of Sicily, the complete paper being published in vol. 18 of the 'Annali dell' Ufficio centrale Meteorologico e Geodinamico.' Marked disturbances were noticed due to the volcanic rocks. From the results of his measurements and of those made in 1882 by Chistoni, the author finds the following values for the secular change for the epoch 1881–1891:—

Declination	$-5'\cdot6$ per annum.
Dip	$-1'\cdot4$,,
Horizontal force	$+0\cdot000017$,,

W. W.

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271. *Electric Point Discharges.* **S. Arrhenius.** (Annal. Phys. Chem. 63. pp. 305–313, 1897.)—The strength of an electric point discharge is measured by a torsion due to the reaction of the point. A wire cross bears four needle-points at its ends, turned at right angles to the arms, all in one direction. The cross is suspended by the centre by means of a metallic wire inside a vessel in which the pressure of the gas can be regulated. An electrometer and a galvanometer are inserted in the circuit, and also an influence-machine which supplies the current. The amount of the torsion is measured by a mirror attached to the cross. On inserting a large condenser in the circuit, the deflection becomes very constant. It is found to increase a little more slowly than the quantity of electricity issuing from the points. In all cases, the quantity of electricity leaving the points is less in the case of negative than in the case of positive electricity. This is the more clearly shown the lower the pressure. It is possible that the reverse is the case at a pressure of several atmospheres. In the more permanent gases, the reaction of the wheel is proportional to the pressure of the gas. In others, like acetone or ethyl ether, it increases more rapidly. This rule, however, only applies to positive electricity. For negative electricity, the reaction always increases more rapidly than the pressure. E. E. F.

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272. *Electric and Magnetic Wind.* **O. Lehmann.** (Annal. Phys. Chem. 63. pp. 285–304, 1897.)—The phenomenon of electric wind is capable of explaining certain properties of stratified discharges and of the arc. When discharge takes place between two plates provided with points, air-currents are set up symmetrically from both sides. They may be made visible by means of tobacco smoke, or by introducing a heavier gas which produces

refraction. The whirls produced may be explained by supposing that particles are projected from each point towards the opposite point and plate. As regards the explanation of this projection, the electrification theory is untenable, and the dissociation theory meets with a difficulty in the case of monatomic gases. If a layer of gas intervenes between the two plates which from any cause has a different dielectric constant, partial discharge takes place within it, and stratification is produced. Electric wind is the cause of the unsymmetrical shape of the arc, which is blown away from the negative pole. If the electric wind occurs in a strong magnetic field the stream lines of the ions, and hence also of the air, must be charged in obedience to the electromagnetic forces, and the new stream may be designated by the term "magnetic wind." An arc playing between the inner edge of a carbon-circle and a rod in its centre rotates rapidly when placed in a magnetic field with its lines of force normal to the plate. In a large highly-exhausted "electric egg" a comet-like phenomenon sometimes projects towards one side, which rotates round the line joining the electrodes when a magnet is approached to it from the outside. This is also probably a phenomenon of magnetic wind. E. E. F.

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273. *Influence of Magnetism on Vacuum Discharges.* **A. Paalzow** and **F. Neesen.** (Annal. Phys. Chem. 63. pp. 209–220, 1897.)—To ensure the symmetrical influence of the magnetic field upon the vacuum-tube, the authors used either a strong magnetising coil or perforated pole-pieces, instead of laying the tube across the poles. When a vacuum-tube is introduced into the perforations of the two pole-pieces, the portions of the tube lying inside the iron suffers no influence, but the portion between the two pole-pieces is subjected to a field symmetrical from every side. In the case of the magnetising coil the influence increases towards the axis, whereas in the case of the hollow pole-pieces it increases towards the walls of the tube. To examine simultaneously the effect of the field in an axial and equatorial direction, a compound vacuum-tube was made in the form of a cross, so that the direction of the discharge could be made parallel or perpendicular to the lines of force at will.

In the axial position, the magnetic field acts as if it increased the pressure of the air which is being pumped out. It therefore retards the setting-in of the discharge, and prolongs it after the minimum pressure has been passed. The action is reversed, however, when the kathode itself is brought under the influence of the field, instead of the space between the two electrodes.

In the equatorial position, the magnetic field always reduces the intensity of the discharge, or even extinguishes it. These influences are accompanied by modifications in the light phenomena of the discharge. In the axial position, when the kathode itself is exposed to the field, the outermost kathode layer is quite blown away, and the other layers are compressed about the kathode. In

the equatorial position, the negative light is extinguished and the positive light is pressed against the wall. The path of the current is thereby lengthened, and the current is eventually broken. A decided difference between paramagnetic oxygen and diamagnetic hydrogen was not shown. There is a certain amount of magnetic time effect, which the authors explain by a charge imparted to the individual molecules before the discharge sets in. E. E. F.

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274. *Positive Light and the Dark Kathode Space.* **E. Wiedemann.** (Annal. Phys. Chem. 63. pp. 242–245, 1897.)—In high vacua, the resistance of the gas increases as the distance between anode and kathode is diminished. The author tested whether this is due to an influence of the dark space upon the anode itself or upon the positive light. He prolonged the anode by means of an inner tube penetrating into the dark space, and observed that the positive stratifications on issuing from the tube bent round backwards until they amalgamated with the negative glow-light. The current passes through the positive strata into the negative glow-light and thence through the dark space. Any disturbance of this sequence is compensated by a deformation of the light-effects.

E. E. F.

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275. *Kathode Rays.* **M. Lamotte.** (Écl. Électr. 13. pp. 444–455, 1897.)—Contains an account of recent work, chiefly by E. Wiedemann, Ebert, and Schmidt, on the nature and properties of kathode rays, and the classification of the spectra of vapours when rendered luminous by the electric discharge. J. L. H.

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276. *Phosphorescence and Kathode Rays.* **A. Sandrucci.** (N. Cimento, 6. pp. 322–325, 1897.)—When the discharge of electricity through a glass tube showing kathode rays is stopped, the glass exhibits phosphorescence. This may be either true phosphorescence, fluorescence due to continued emission of kathode-rays, or both combined. The author has examined these hypotheses, using various tubes inserted between the poles of a large horseshoe electromagnet; the magnet was sometimes excited during the passage of the electricity, and in other experiments only after the current of the induction-coil had been stopped. The results indicate that the kathode continues to emit kathode rays, which can be deflected by a magnet, for an appreciable time after the electric discharge in the tube has ceased. The residual fluorescence of the glass shows patches of greater intensity when the magnet is excited, which shift in position on breaking the current of the electromagnet. Further, the luminosity of the glass is a true phosphorescence.

The author points out that this behaviour of kathode rays does not admit of any simple explanation on the hypothesis that the rays are streams of negatively charged molecules, whereas it might

be due to a vibration in the ether set up by the kathode, analogous to the vibrations of a tuning-fork after the operation of bowing it has ceased. J. L. H.

277. *Electrostatic Properties of Kathode Rays.* **W. Wien.** (Berlin Phys. Gesell. Verh. 16. pp. 165–172, 1897.)—The English physicists regard kathode rays as streams of negatively-charged particles: the German as processes in the ether. Wiechert has supposed them to consist of particles probably smaller than ordinary molecules: so has J. J. Thomson. If the kathode rays after passing through an aluminium window put to earth still bore negative charges, the hypothesis of charged particles would be the correct one; and the author shows that they do so. The rays bent by a magnet carry negative charges; those not deflected carry positive, but these do not get through aluminium. This points towards the latter consisting of larger particles than the former. The author has found magnetic deflection of the rays traversing a Lenard window, to an extent corresponding to a velocity equal to about one-third the velocity of light. A. D.

278. *Crookes Tubes.* **V. Machado.** (Comptes Rendus, 125. p. 945, 1897.)—In a Crookes tube containing the Maltese cross soldered to the anode there is, besides the shadow of the cross, a circular shadow on the antikathodic wall. This shadow is smaller than the cross. When a magnet is brought near, both shadows travel from the mid point; but the circular shadow travels much more than the cruciform one, and places itself at right angles to the magnetic field. The former seems to be the base of a conical region at right angles to the kathode disc; and this conical region seems to be devoid of any useful radiations. The active kathode rays then come only from the edges of the kathode disc; and the green fluorescence is in a ring outside this circular shadow. A. D.

279. *Electric Waves and Dust Figures.* **W. von Bezold.** (Annal. Phys. Chem. 63. pp. 124–131, 1897.)—The author describes the apparatus used in 1870 for the dust-figure experiments quoted by Hertz as to some extent anticipating his own work on electric waves. E. E. F.

280. *Hertzian Waves.* **E. Ducretet.** (Paris. Soc. Franç. Phys., Bull. 104. pp. 3–4, 1897.)—M. Ducretet showed the Society a very convenient form of oscillator and coherer. He described the apparatus used by Popoff at St. Petersburg in 1895: a coherer is placed in circuit with a relay which is set in action when the waves render the coherer conductive. The relay works a bell-hammer which also strikes the coherer, and a recording-point. M. Ducretet has modified this apparatus so as to make a working telegraphic recorder. A. D.

281. *Interferometer for Electric Waves.* **G. F. Hull.** (Phys. Rev. 5. pp. 231–246, 1897.)—The principle of Michelson's interferometer is applied to electric waves. The radiation from two spheres, sparking to each other in oil, is concentrated by a suitable parabolic mirror on a sheet of cardboard carrying parallel strips of tinfoil; by this means the radiation is half transmitted and half reflected. The two beams are made to return on their paths by reflection from plane mirrors, which can be moved in the direction of the beam; ultimately they fall on a receiver and produce interference. The receiver used, a coherer, consisted of small nails or pieces of wire about 1 cm. long, contained in a glass tube filled with oil, and was connected up to a cell and galvanometer.

The curve of interference was constructed by observing the change of resistance of the coherer brought about by the joint action of the two waves, as one mirror was altered in position. From the maxima and minima on this curve the wave-length was determined; and the effect of damping of the vibrations, both in the vibrator and the receiver, was clearly shown in the curves. The author concludes that the logarithmic decrement of the amplitude of oscillation is of the same order for the receiver as for the vibrator. From a number of interference-curves the period of the principal component in the radiation from the vibrator may be determined; and when the instrument is used as a refractometer the error in the index of refraction need not exceed one per cent.

J. L. H.

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282. *Behaviour of Selenite in an Electric Field.* **A. Righi.** (N. Cimento, 6. pp. 345–349, 1897.)—The equality of dielectric constant and square of refractive index, for dielectrics crystallising in the second, third, or fourth systems of crystals, requires that the axes of optic elasticity and those of electric polarisation must be coincident. The author has already determined the axes corresponding to the three principal indices of refraction for electromagnetic waves in selenite (see Phys. Soc. Abstracts, No. 416, July 1897, and No. 538, Sept. 1897). In the present paper he describes experiments to determine whether, in the case of selenite, the axis of maximum dielectric constant coincides with that of maximum refractive index—namely, the direction of the secondary non-fibrous cleavage. Circular discs of selenite were suspended horizontally by quartz fibres in an alternating electric field set up between two parallel plates. The plates formed the ends of a system of Lecher wires in which electric oscillations were excited, the wires being connected by metal bridges at suitable points. The frequency of the waves was about 20 million per second. It was found that the disc always tended to set itself with the direction of non-fibrous cleavage along the lines of force, and was only prevented from doing so by the torsion of the fibre. When the disc was placed with the axis of non-fibrous cleavage

parallel to the axis of the plates, it did not move on setting-up the electric field. The author therefore concludes that Maxwell's relation is true in the case of selenite. J. L. H.

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283. *Clark Cells.* **A. Dearlove.** (Electn. 40. pp. 386–387, 1898.)—The author defends the Clark cell as a reliable and durable standard, but prefers Clark's original process for setting it up to that which is specified by the Board of Trade. He gives the results of tests made on 21 cells recently set up from the same stock materials, the process being slightly varied. The results of the first 16 cells show a maximum variation between themselves of 4 parts in 10,000, and compare well with the value of the standard ; the results of the last five, prepared according to the Board of Trade specification, are much less satisfactory. The platinum spirals are most easily amalgamated by placing them in boiling mercury. A. H. A.

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284. *Precipitation Primary Batteries.* **R. Lorenz.** (Zeitschr. Elektrochem. 4. pp. 305–309, 1898.)—In the majority of galvanic cells the electrolyte undergoes change, and has to be renewed from time to time; but by an adaptation of the author's method of preparing metallic hydroxides, cells can be constructed in which the chemical changes are virtually confined to the electrodes. The metal—zinc, for example—is placed in a solution of an alkali chloride, such as common salt, the other electrode consisting of platinum, copper oxide, or other suitable material; and on completing the circuit the metallic ions liberated at the kathode combine with the hydroxyl ions from the anode, and the metallic hydroxide is precipitated, the sodium chloride remaining unchanged. Numerous data are given concerning a zinc|common-salt|copper-oxide element constructed on this plan. The electrodes are plates 67×99 mm., about 30 mm. apart, and the salt solution contains 58·4 grams per litre. With an external resistance of 170 ohms the E.M.F. falls in the course of sixty-five hours from 0·99 to 0·70 volt, remaining stationary at about 0·9 volt for two or three hours after the initial drop. With 10 ohms the E.M.F. falls quickly to about 0·5 volt, and there remains constant for several hours, and the total quantity of electricity generated during this time amounts to about 65 ampere-minutes. The gelatinous precipitate of zinc hydroxide which gradually accumulates hinders free circulation ; but with low external resistances the E.M.F. at once regains its original value on stirring. With 1 ohm, for example, the original E.M.F. of 0·27 volt, which in the course of 5 hours drops to 0·14 volt, thus immediately recovers; the total quantity of electricity amounts, as before, to about 68 ampere-minutes. The E.M.F. throughout is from 0·25 to 0·5 volt lower than with Umbreit's

"cupron"-element (zinc | caustic-soda | copper-oxide). Direct potential measurements with the aid of an auxiliary mercury | mercurous-chloride | potassium-chloride cell show that the falling-off of the E.M.F. takes place principally at the anode; and this is also the case with the "cupron"-element. These precipitation-cells work well at current-densities up to 0·005 ampere/cm.^{2}, and the exciting fluid is cheap and inoffensive; but against these advantages must be placed the low E.M.F. and the trouble of frequently removing the precipitated hydroxide. They mark a further step, however, towards the solution of the problem of converting the energy of coal directly into electrical energy, since the metal can be reproduced from the hydroxide in one operation by heating the coal. Similar cells can be formed with cadmium (0·632 volt), iron (0·297 volt), and magnesium (1·528 volt); in each case the gelatinous hydroxide of the metal being precipitated and the sodium-chloride solution remaining unchanged. J. W.

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285. *Shunt-Box Compensation.* **W. M. Stine.** (Amer. Journ. Sci. 5. pp. 124–125, 1898.)—The compensating resistances for keeping the resistance of a shunted galvanometer constant are ordinarily inserted between the galvanometer and the shunt. The shunting and compensating resistances are then fractions of the galvanometer-resistance which cannot be expressed simply, and are consequently difficult of adjustment. The author describes a shunt-box in which the compensating resistances are in the galvanometer-circuit outside the shunt. They are inserted together with the shunts by three-part plug sockets; one part is connected to the galvanometer, a second to the shunt, and the third to the outside circuit through the compensating resistance. The shunting resistances are then the ordinary simple fractions of the galvanometer-resistance, and the compensating resistances the fractions 0·999, 0·99, and 0·9, etc. If, therefore, three resistances of the fractional values 0·009, 0·09, and 0·9 are joined in series, the compensations are made by including one, two, or all three in circuit. G. H. Ba.

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286. *Measurement of Self-Induction by Alternating Currents.* **K. E. Guthe.** (Amer. Journ. Sci. 5. pp. 141–143, 1898.)—The author discusses some points in Rowland's paper on measurement by alternate currents (Abstract No. 144, Feb. 1898), and describes a method of measuring self-induction based on the same principle as Rowland's methods, which is especially adapted to measuring self-inductions comparable with, or smaller than, those of the dynamometer coils. Two separate currents from a two-phase generator, differing 90° in phase, are sent through the two dynamometer coils, and the dynamometer balanced to zero by adjustment of the resistances in circuit. The arrangement is calibrated by measuring the extra resistance required to again obtain balance when a standard self-induction is put in one of the circuits. If a

second balance be made with the unknown self-induction in circuit, the two self-inductions are proportional to their balancing resistances. G. H. Ba.

287. *Self-Induction Measurements.* **Thiermann.** (Elect. Runds. 15. pp. 32–33, 1897.)—A description is given of a method devised by Thiermann for the measurement of coefficients of self-inductions. The self-inductive conductor under test is connected, in parallel or otherwise, by means of a special key, to a non-inductive conductor of equal resistance. One pair of extremities of the two conductors is permanently joined; the other pair may be joined or disconnected by the key. This second pair of extremities is also connected to a ballistic galvanometer. When the key is closed the galvanometer is short-circuited, and the two conductors are thus connected in parallel. When the key is open, the two conductors and the ballistic galvanometer are in simple circuit with one another. The current through the self-inductive conductor is, for steady currents, measured by an ammeter. A battery is connected between the first pair of extremities of the two conductors and the lever of the key; the battery-circuit is consequently open when the key is open, and closed when the key is closed. The current through the battery is regulated by a rheostat.

In order to make a measurement, the key is first closed, and the rheostat is adjusted to give a convenient current as read by the ammeter in series with the self-inductive conductor. This current is observed. For the second operation, the trigger of the key is released: this breaks the battery-circuit, and simultaneously puts the ballistic galvanometer in series with the two conductors. The corresponding "throw" of the ballistic galvanometer, resulting from the momentary induced E.M.F., is then observed. Finally, a relation is found which determines the self-induction of the given conductor, in terms of these two measurements and the known resistances. In the paper this relation is wrongly stated: self-induction appears as a resistance, which is impossible. More correctly: the required self-induction is proportional to the quantity of electricity discharged through the ballistic galvanometer at the second operation, divided by the steady current measured in the first, and multiplied by the resistance of the circuit containing the two conductors in series with the ballistic galvanometer and the ammeter. The limits of accuracy depend very much upon the perfect working of the key, since if it does not release the two contacts simultaneously the galvanometer is deflected by a fortuitous current. R. A.

288. *Induction Coils.* **B. Walter.** (Annal. Phys. Chem. 62. pp. 300–322, 1897.)—The author studies the form of the discharge by means of the magnetically displaced phosphorescent patch used by Braun. He finds that, apart from the losses of electrical energy

due to the spark at break, to magnetic and dielectric hysteresis, and loss in heating the circuit, the maximum value of the secondary E.M.F. in an induction-coil is directly proportional to the maximum intensity attained by the primary current and to the square root of the inductance of the secondary coil, and inversely proportional to the square root of the capacity in the primary circuit. Since it is easy to raise the intensity of the current at make, it is important to regulate the interruptor so as not to break down the insulation of the secondary. E. E. F.

289. *New Induction Coil.* (Elect. World, 31. p. 98, 1898.)—This is a description of an induction-coil suitable for Röntgen-ray work which has recently been constructed by Messrs. Rochefort and Wydts. In their transformer the primary is the same as that of a Ruhmkorff coil, with a laminated core on which is wound a double layer of coarse wire leading out to binding-screws. A tube surrounds the primary for its whole length. The secondary spool is comparatively short, and is placed around the middle of the primary coil. It rests between annular discs of glass supported by a wooden block. The two terminals of the secondary coil are attached to two screws inserted in the openings of two glass stoppers. The wires and leads are surrounded by a hydrocarbon insulator. The apparatus is constructed to give a discharge of 20 to 22 centimetres in length with 3·3 amperes at 6 volts applied between the primary terminals. W. G. R.

290. *Phase-meter for Alternating Currents.* **J. Tuma.** (Berlin. Akad. Sitzber. 106. pp. 442–452, 1897.)—The instrument consists of two coils, about 15·5 cms. and 18 cms. respectively in diameter, and 3 cms. wide, placed with their planes normal to each other and the axis of one of the coils in the magnetic meridian. At the centre of the coils is suspended a carefully annealed needle of soft iron, whose deflection is a measure of the phase-difference between the two currents traversing the coils of the instrument. Let I_1 and I_2 denote the two currents, $c_1 I_1$ and $c_2 I_2$ the maximum values of the magnetic fields due to them, ϕ the angle of phase-difference, ψ the angle between the needle and the normal to the coil whose axis lies in the magnetic meridian, and H the earth's horizontal component. The author shows that

$$\tan 2\psi = \frac{2c_1 c_2 I_1 I_2 \cos\phi}{c_1^2 I_1^2 - c_2^2 I_2^2 + 2H^2}.$$

By making $I_1 = I_2$, and winding the coils so that $\frac{c_1}{c_2} = 2{\cdot}4142$, the term involving H may be neglected, and the formula becomes

$$\cos\phi = \tan 2\psi.$$

For securing exact equality of currents, the author uses a somewhat complicated bolometric arrangement. The use of the

instrument is illustrated by some measurements made with it of the power-factor of a transformer at various loads. In its present state the instrument is far from being a commercial one; but the author hopes to reduce it to that form. A. H.

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291. *Use of Imaginary Quantities in Alternate-Current Problems.* **P. Janet.** (Écl. Électr. 13. pp. 529–531, 1897.)—If A be any alternating function of which the phase is ϕ, it may be represented by the formula

$$[A]=A(\cos\phi+i\sin\phi).$$

If the electromotive force expressed in this form be [E], [I] the intensity, we have $[I]=\frac{[E]}{r-is}$, where r is the ohmic resistance, $r-is$ the impedance.

M. Janet proposes to extend the principle as follows:—If E be the effective E.M.F. of an alternating generator,

$$[E]=E(\cos\phi+i\sin\phi).$$

If the generator be traversed by a current I with phase ϕ',

$$[I]=I(\cos\phi'+i\sin\phi').$$

The real part of [E] is $E\sqrt{2}\sin(\omega t-\phi)$, that of [I] is $I\sqrt{2}\sin(\omega t-\phi')$. The energy is actually $EI\cos(\phi-\phi')$. We ought to find that [E] [I] has for its real part $EI\cos(\phi-\phi')$. In order that this may be so, we must proceed according to the following rule, namely, use $-i$ instead of i in one or other of the two factors [E] and [I], and then take the real part.

M. Janet then gives an example:—E_1 being the effective E.M.F. of a generator, E_2 that of a motor; the phase of the latter is θ_1. The total E.M.F. is

$$E_1+E_2(\cos\theta+i\sin\theta),$$

and for the current,

$$[I]=\frac{E_1+E_2(\cos\theta+i\sin\theta)}{r-is}.$$

Then, according to the rule above found, the electric power given by the motor is

$$-E_2(\cos\theta-i\sin\theta)\frac{E_1+E_2(\cos\theta+i\sin\theta)}{r-is},$$

of which the real part is

$$-\frac{E_1E_2(r\cos\theta+s\sin\theta)+rE_2^2)}{r^2+s^2},$$

a known formula. S. H. B.

292. *Alternate-Current Problems.* **C. F. Guilbert.** (Écl. Électr. 14. pp. 69–70, 1898.)—Referring to the work of M. Janet, the author points out that Steinmetz had calculated the real part of [EI] thus, writing

$$E = a + b\sqrt{-1}.$$
$$I = c + d\sqrt{-1}.$$

Steinmetz gets for the real part of EI, not $ac - bd$ but $ac + bd$, which agrees with Janet's rule. Steinmetz also uses $P = \rho E^2$, where ρ is the conductance $\frac{r}{r^2 + s^2}$. S. H. B.

293. *Change in Length by Magnetisation.* **B. B. Brackett.** (Phys. Rev. 5. pp. 258–284, 1897.)—The paper contains an account of some careful experiments on the permanent and temporary elongations (+ve and −ve), produced by fields up to about 300 units, of soft iron and pianoforte wires. On the hypothesis that when iron is magnetised, a *mechanical* compressive force is produced equal to $B^2/8\pi$, or perhaps to $(B - H)^2/8\pi$, the author calculates what portions of the elongations are due to purely magnetic action.

Tables and curves give the reader a rapid comprehension of the experimental results; but, owing to no fault of the worker, no brilliant generalisations have been deduced. A. Gs.

294. *Magnetic Properties and Chemical Composition of Iron.* **B. S. Summers.** (Soc. Chem. Ind. Journ. 16. pp. 998–1002, 1897.)—If the proximate analysis of iron by microscopic and other methods could be carried out more completely, it would doubtless be possible to establish relations between its physical properties and its proximate composition. The author has examined the influence more especially of non-metallic impurities on the magnetic permeability and hysteresis of iron. High permeability and low hysteresis usually, but not invariably, accompany each other. Experiments with cast-iron were difficult to interpret owing to the numerous impurities; special samples of cast-iron were therefore prepared with varying quantities of silicon and phosphorus. These contained about 2·5 per cent. of combined carbon and mere traces of graphitic carbon. Comparisons of their magnetic permeability show that the presence of silicon up to 3·66 per cent. has no marked effect, the same being true of phosphorus between 0·269 and 1·766 per cent. In this series of mixtures those samples containing least carbon had the highest permeability. Microscopic examination showed that the carbon was present mainly in the form of carbide. The presence of manganese in quantities less than 1 per cent. has also a very small effect on the magnetic permeability, especially when much carbon is present; the small influence noticed appeared to be due to the effect of the manganese in increasing the amount of combined carbon. The same is true of sulphur; the experiments were made with a semi-steel (con-

taining 40 or 50 per cent. of steel-rail scrap), in which the carbon was present mainly in the graphitic form. This metal contained about 2 per cent. of carbon, and the addition of more than 0·13 per cent. of sulphur made the metal very white and hard. The addition of 0·75 per cent. of silicon to this steel had no appreciable effect on its permeability; the total silicon was, however, always above 3·75 per cent., so that the variations tried did not affect the condition of the carbon. Although the increase of the silicon had no effect on the permeability, it diminished the hysteresis-loss very appreciably. When more than 1 per cent. of phosphorus is present, a further increase has no effect on permeability or hysteresis. The influence of both the silicon and the phosphorus appears to be indirect and due to their effect on the condition in which the carbon exists. This latter is the main factor to be considered; in general, a low percentage of carbon is accompanied by high permeability and low hysteresis-loss; but this is not always so, and the author supposes that the permeability is mainly affected by some special form of combined carbon, probably Ledebur's "hardening carbon"—the Martensite of the microscopists. Graphite appears to be inert, merely giving the metal a more open texture and lesser density; if it could be removed without increasing the combined carbon, the permeability would be higher. Micro-photographs showing the structure of several of the samples examined are given. In conclusion it is pointed out that the physical state of the metal may be of importance. An iron, almost free from carbon, may have a comparatively low permeability which will be changed to an unusually high one by annealing. This may be due to the removal of an internal stress or to the existence of an allotropic modification of iron. Notwithstanding this, the magnetic properties may often be calculated with fair accuracy from the chemical composition. T. E.

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295. *Magnetic Properties of Basalts.* **F. Pockels.** (Annal. Phys. Chem. 63. pp. 195–201, 1897.)—Rectangular rods of various specimens of nepheline basalt were tested by the magnetometric method. The general appearance of the magnetisation-curves is the same as in soft iron. Both the temporary and the remanent magnetisations increase more rapidly than the field at first, and afterwards less rapidly. The ratio of the remanent to the temporary magnetism increases at first with the field, but then becomes constant, and finally decreases. In the basalts containing the larger magnetite-crystals, the remanent reaches its maximum sooner than in the others. The magnetic properties of basalt may be used for an approximate determination of the current intensity of a lightning flash. Certain outcrops show an irregular and purely local magnetisation which can only be due to discharges of atmospheric electricity. Cutting rods out of these rocks, and determining the field necessary to produce the permanent magnetisation they actually possess, it is only necessary to have some idea of the distance at which the lightning passed to be able to gauge its current strength.

As a rule, it may be assumed that the discharge passes along the surface of the rock. Sometimes a damaged tree will give some indication. One such rough estimate led to a minimum value of 2900 amperes for the current intensity. Three specimens obtained from the neighbourhood of damaged trees gave 6400, 6600, and 10,800 amperes respectively, which are probably still too small.

E. E. F.

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296. *Concussion and Magnetism.* **C. Fromme.** (Annal. Phys. Chem. 63. pp. 314–323, 1897.)—Electric oscillations do not influence the susceptibility for permanent magnetism, either in an iron wire or a tube filled with iron-filings, although they may change the electric conductivity within wide limits. On the other hand, a large modification of the magnetic moment of the coherer may be without influence upon the electric conductivity. The change of electric conductivity takes place between the filings, the change of magnetisation within them. Electric discharges passing *through* the wire or the tube affect the magnetisation as concussion does. Concussions applied before magnetisation cannot, even if very numerous, produce the minimum susceptibility for permanent magnetism. This can only be attained by repeated alternation between concussion and magnetisation. On concussion the permanent moment always falls to the same amount, whatever the susceptibility. The loss of moment by concussion decreases as the alternating process is repeated, until the minimum susceptibility is attained. But in every case, the loss by concussion is proportional to the initial permanent moment. E. E. F.

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297. *Shielded Conductors.* **W. A. Price.** (Elect. Rev. 42. pp. 61–63 and pp. 68–69, 1898.)—This is an explanation why a conductor buried in the iron of a slot-wound armature experiences very little mechanical force, though it is equally as efficient in developing electromotive force in a dynamo, as if it were exposed on the surface of an ordinary drum armature, and has just the same effect in producing torque in a motor. The explanation given is that in a slot-wound armature the conductors are so shielded by the iron body in which the slots are cut, that only a very small part of the total magnetic flux passes through them at any given instant, and the force acting on the conductor is correspondingly small; while at the same time the total flux cut by any conductor in the course of the revolution of the armature is not affected. It is at the same time stated that the field in the body of the conductor is extremely weak, but as the armature is rotated the lines of flux are carried across the conductor, moving slowly in the mass of iron but flashing across the slot at great speed. Another point discussed is the comparative freedom from eddy currents in the conductors of slot-wound armatures, but no explanation of this is given. W. G. R.

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298. *Magnetic Screening.* **H. Du Bois.** (Berlin. Phys. Gesell. Verh. 16. pp. 180–182, 1897.)—This is a preliminary communication on the magnetic protection which single or double shell cylinders or spheres, whose shells are separated by layers of non-magnetic materials, afford to objects within or without the spheres. For a given weight, the degree of protection depends upon the ratio of the radii of the spheres and intermediate layers. The theoretical results have been confirmed for simple spheres by experiments with iron filings, and for multilamellar spheres by experiments on the deflections of magnetic systems. The multi-lamellar spheres prove much more effective than simple shells. As regards the screening of objects at a distance, the formulæ are, strictly speaking, applicable only to cylinders of infinite length; but conclusions may be drawn as to cylinders whose length is not less than twice the diameter. A method of determining the permeability of lamellæ for transformers, etc. has been deduced; and the paper further concerns the screening of wires within armoured couples or in the perforations of dynamo armatures. H. B.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

299. *Possible Change of Weight in Chemical Reactions.* **F. Sanford** and **L. Ray.** (Phys. Rev. 5. pp. 247–253, 1897.)—The authors have repeated Landolt's work (Zeit. Phys. Chem. 12. p. 1, 1894, and Ibid. 12. p. 31, 1893), but using the reduction of silver from an ammonia solution of the oxide by means of grape sugar instead of the reaction between silver and ferrous sulphate as used by him. They conclude that while their weighings show much greater irregularities than those of Landolt, they are still accurate enough to make it extremely improbable that the reaction was accompanied by any such change of weight as was observed in the similar reaction used by him. S. R.

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300. *Molecular Volumes of Gases.* **A. Leduc.** (Paris. Soc. Franç. Phys., Bull. 104. pp. 1–3, 1897.)—Having ascertained as precisely as possible the densities of 23 gases in the pure state, from Stas' molecular weights he calculates the molecular volumes at 0° and 76 mm. as compared with those of a perfect gas. His result is that at any temperature T° and pressure p cm. the molecular volume for normal gases is

$$v=1-[y+(e-1)z+(e-1)^2u]10^{-4},$$

where $y=72\chi^4-130\chi^3+172\chi^2-83\chi+12{\cdot}3$, χ being Θ/T, where Θ is the critical temperature; e is p/π, where π is the critical pressure; z is $101{\cdot}4\chi^4-220\chi^3+266\chi^2-119\chi+16{\cdot}9$; $u=20\chi(\chi-1)$. For more compressible gases (CH_4, C_2H_6, NH_3, CH_3Cl), y, z, and u must be multiplied by 1·16: for less compressible (H_2S, PH_3), y must be multiplied by 0·93, and z and u by 0·84. The coefficients of dilatation are also worked out in detail; and the conclusion is reached that nitrogen obeys Boyle's law at 100°, carbon dioxide at 620°, and sulphurous anhydride at 985°. A. D.

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301. *Calcium Carbide as a Reducer.* **H. Moissan.** (Écl. Électr. 14. pp. 120–121, 1898.)—Most metallic oxides are reducible by calcium carbide: some, such as those of lead, copper, bismuth, and tin, at a dull red heat; but the majority only by the liquid carbide at the temperature of the electric furnace. The metals of the first class are liberated in the free state, but with the more refractory metals carbides are formed, uncontaminated, however, with calcium. In this manner, with a current of 900 amperes at 45 volts, well-defined crystalline carbides of aluminium, manganese, chromium, molybdenum, tungsten, and titanium have been prepared. The excess of calcium carbide is readily removed by water or dilute acetic acid. Calcium silicide (carborundum) is readily obtained in colourless, or at the most faintly coloured,

crystals in this way by fusing an equimolecular mixture of powdered quartz and calcium carbide, and the process is likely to become of commercial importance. J. W.

302. *Copper-Glucinum Alloys by the Electric Furnace.* **P. Lebeau.** (Écl. Électr. 14. pp. 121–122, 1898.)—On heating oxide of glucinum with charcoal in an electric furnace, glucinum carbide is formed but not metallic glucinum; but on subjecting to the same treatment an intimate mixture of the oxides of glucinum and copper, obtained by evaporating together and igniting solutions of the nitrates, an alloy of glucinum and copper is obtained, free from metallic carbides. The ingots thus prepared show a rose-red fracture, but are not homogeneous, and readily yield on heating an almost colourless product containing from 5 to 10 per cent. of metallic glucinum. The 10 per cent. alloy is almost colourless, the 5 per cent. alloy yellowish. The latter is malleable, both cold and hot, and is readily worked with the file and polished. It does not tarnish in the air, but is slightly discoloured by sulphuretted hydrogen, and is readily soluble in nitric acid. Alloys containing from 1·3 per cent. of glucinum downwards are of a golden yellow or deeper colour; they are very easily worked, and very sonorous. J. W.

303. *Activity of Electrolytic Gases.* **F. Winteler.** (Zeitschr. Elektrochem. 4. p. 342, 1898.)—It is often assumed that electrolytic hydrogen, oxygen, and chlorine are more active chemically than the gases prepared by chemical methods, and it cannot be denied that electrolytically prepared mixtures of hydrogen and chlorine, and even of hydrogen and oxygen, have been known to explode without apparent cause. Bunsen showed years ago that the spontaneous explosion of the hydrogen-chlorine mixture does not occur outside the generating cell, and that it is not due to the presence of hydrochloric acid, since a similar chemically prepared mixture is far less easily fired after saturation with hydrochloric acid gas. As the explosions undoubtedly occur only in the generating vessel, the author thinks that it is unnecessary to assume that the gases are in a specially active (*i. e.* atomic) condition, but that the activity is due to hydrogen absorbed by the kathode. A palladium kathode, for example, saturated with hydrogen and then washed and dried, heats so rapidly in the air as to ignite gun-cotton in a few seconds, and platinum behaves in a similar manner, the temperature rising sufficiently to detonate a hydrogen-oxygen mixture when a kathode of this metal is not completely immersed. Numerical data are promised. J. W.

304. *Hardening Oxide in Accumulators.* **S. Hammacher.** (Écl. Électr. 14. pp. 117–118, 1898.)—Four methods are described of obtaining a hard deposit of lead oxides, and thus enabling the weight of the supporting plates to be diminished. In the first, a mixture of the oxides with coal-tar residues (pitch) and alcohol or

light petroleum is used; but the resulting mass, although not disintegrated by dilute sulphuric acid, has an unduly high resistance. In the second, the oxides are ground up with ethyl butyrate; but in this case the lead combines with the butyric acid on drying the plates, and the hydrides and oxides of carbon disengaged on passing the current partially disintegrate the plates. In the third, the oxides are mixed with glycerine; but here, although stable plates are obtained, the excess of glycerine has to be destroyed by the addition of potassium permanganate to the electrolyte, and thus the cost becomes prohibitive. In the fourth, the litharge or red lead is mixed with picoline, lutidine, etc. (bone-oil), and dried in a stove. The plates thus obtained are stated to be very hard, stable, efficient, and reasonable in price. J. W.

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305. *Electrolytic Zinc.* (Eng. 65. pp. 85–86, 1898.)—Processes for the electrolytic reduction of zinc have not, as yet, been very successful, partly owing to the comparatively low value of the metal, and partly to the small demand for pure zinc. The Broken Hill ore of New South Wales is essentially a mixture of the sulphides of lead, zinc, and silver, which is not resolvable by ordinary metallurgical processes. But by the Ashcroft electrolytic process the zinc, after dissolution in ferric sulphate solution (obtained at a later stage by the action of iron anodes on the zinc sulphate thus produced) can be precipitated electrolytically, and the residual lead and silver then smelted in the ordinary manner. It is doubtful, however, whether the method will pay commercially, the result of a few months' working having been less favourable than was anticipated. In the Siemens-Halske process, also being tried in Australia, sulphuric acid or acid zinc sulphate is substituted for the ferric sulphate of the Ashcroft process, but the results obtained on the large scale have not as yet been published. In Dieffenbach's process, which is being successfully applied at Duisberg, in Germany, to zinciferous iron pyrites, the ore is simultaneously chlorinated and roasted; the zinc is then dissolved out with the effluent zinc chloride from the depositing vats, and the solution electrolysed. Taking the cost of an electrical H.P. hour at 1*s.* 10*d.*, as at Niagara and in Switzerland, and assuming an energy-efficiency of 33 per cent., the energy alone required per ton of zinc reduced costs £3 5*s.* 6*d.*; and to this must be added the cost of working, and charges for interest, depreciation, and royalties; so that there does not appear to be much margin for profit. In the processes for "galvanising" iron the texture of the deposit, which is of course all-important, is somewhat difficult to control. For ordinary work the usual dipping process is not, therefore, likely to be superseded; but in special cases, by paying attention to the current density, to the concentration and composition of the solution, and to the preparation of the article to be coated, a particularly smooth and tenaciously adherent coat of the metal may be obtained. J. W.

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306. *Purification of the Electrolyte in Copper Refining.* (Electn. 40. pp. 523–524, 1898.)—This is an abstract of a paper by **T. Ulke** in a recent number of the 'Zeitschrift für Electrochemie.' At the Baltimore Copper Co. about one-fifth of the electrolyte is removed from time to time, and pure copper sulphate solution is added so as to adjust the strength of the electrolyte in copper sulphate to its normal value whilst reducing the amount of impurities. From the liquor removed, $CuSO_4$ is obtained and sold, the final or mother liquors being precipitated with iron scrap to recover the remaining 2–3 per cent. of copper. At the works of Guggenheim Bros., Perth Amboy, a method analogous to that of K. and H. Borchers is employed, in which the liquid of each tank is simultaneously circulated and aërated by a jet of air at a pressure of 3 or 4 lb. per sq. in. blown into a vertical tube open at top and bottom so as to allow the electrolyte to enter below and to be ejected above. In addition to this the electrolyte needs periodical replacement, the liquor being run into lead-lined vats and boiled with scrap-copper with free access of air. In this manner the free acid is neutralised, and the solution so enriched in copper sulphate that it can be readily crystallised to yield this salt, which is deposited on lead strips hung across the crystallising tank. The mother liquor contains almost the whole of the antimony and arsenic together with a small quantity of copper. The latter is precipitated by iron plates on which the arsenic is afterwards deposited in the form of a black precipitate containing about 60 per cent. As. From this, crude Cu or arsenic compounds, such as Scheele's green, Paris green, or white arsenic can be obtained. In the Chicago Copper Refinery, the bulk of the copper-sulphate is obtained by crystallisation, and the mother liquor is boiled down to a point at which both copper sulphate and arsenious acid crystallise out. The mixture is extracted with just enough water to dissolve the copper sulphate, which, being thus fairly freed from arsenic, is returned to the vats. Other methods include boiling the liquor with metastannic acid to precipitate As; filtration of the liquor through a layer of cuprous oxide to precipitate most foreign metals as hydroxides, and the oxidation of other impurities, notably iron, by aëration ; other impurities, *e. g.* arsenic, being precipitated as ferric arseniate. A good method is to electrolyse the liquors from the vats with a current-density so high that all impurities save iron are deposited pell-mell with the copper, using sheet-copper kathodes and lead anodes. This is of advantage where the metal, although impure, is more saleable than copper sulphate. The liquor, free from As and Sb but still containing Fe, is brought up to strength with fresh $CuSO_4$, this process being repeated until the percentage of Fe becomes too great, when the liquor is finally worked up for copper sulphate. C. K. F.

GENERAL ELECTRICAL ENGINEERING.

307. *Accumulator Plates.* **F. W. Greengrass** and **S. R. Dockings.** (Écl. Électr. 14. pp. 70–71, 1898.)—Lead spirals, cut on a lathe from a cylinder of the metal, are pressed flat on either side of a rigid support, and soldered in position. The plates thus constructed are then "formed" in the usual manner. J. W.

308. *Accumulator Plates.* **F. Grunwald.** (Écl. Électr. 14. p. 71, 1898.)—Two grids of the usual type are clamped on either side of a third, to which the small squares of metal, usually cut away, are left attached by one side and bent over at right angles to form supports for the oxide when the cell is "formed." J. W.

309. *Supporting Accumulator Plates.* **G. Fabro.** (Écl. Électr. 14. pp. 71–72, 1898.)—Two clamps are described. The first, which is intended for use in mechanical traction, consists of two blocks of wood, connected by two bolts passing through stout indiarubber buffer-cylinders, allowing a certain amount of play. In the second, which is intended only for stationary accumulators, connection is made through sliding-rods, carrying hinged jaws on which the plates rest and which grip the tighter, the heavier the load. J. W.

310. *The "Hatch" Secondary Battery.* (Electn. 40. pp. 381–382, 1898.)—The usual paste of peroxide is plastered on porous grids of baked china-clay or the like, and the plates thus made are built up into blocks with sheets of lead, the whole being bound together by thick outer slabs of insulating material bolted or clamped to each other, and the alternate lead plates connected up in the usual way. The unpasted sides of the porous grids being channelled to allow of the escape of gases, and it being practically impossible for the paste to break away, an unusually long life is said to be secured for the cell, and the risk of injury from excessively rapid charge or discharge considerably reduced. The internal resistance is said to be reasonably low. J. W.

311. *Lathe for Commutator Turning.* **M. Aliamet.** (Électricien, 15. pp. 57–58, 1898.)—This is an illustrated description of an arrangement for turning up the commutator of a dynamo without the necessity of taking the armature from its position between the field-magnets. The arrangements, with complete set of turning tools, are constructed by Messrs. Honeywood and Austin of London. W. G. R.

312. *Electrical Steering Gear.* **M. Pfatischer.** (Elect. Engr. N. Y. 25. pp. 68–69, 1898.)—An arrangement is described for electrically controlling the valve-gear of a steering engine of the ordinary type. The apparatus consists of a forward-rheostat near

the bridge, and an after-rheostat in the steering-engine room, together with a $\frac{1}{2}$ H.P. electromotor and a motor-generator. The rheostats are joined across the ship's electric circuits; from a movable contact-arm on the forward-rheostat a single balancing-wire is led, through the field circuit of the generator, to the corresponding arm on the after-rheostat.

The movable arm of the forward-rheostat is geared to the steering wheel, so that when the latter is rotated the arm is moved and an electric balance is disturbed, causing a current to flow in the balancing-wire; this excites the field of the generator, which then supplies current to the $\frac{1}{2}$ H.P. motor. The latter is geared to the valve of the engine and the movable arm of the after-rheostat; both are set in motion, and continue to move until the electric balance is restored, when the motor comes to rest. No electric circuits are interrupted, so that there is no sparking; and the motor runs either way, according to the motion of the steering wheel. To prevent accident, the motor actuates the valve through a spring attachment. No diagram of connections is given.

A. H. A.

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313. *Effect of Vibrations on Thomson Meter.* **E. O. Keenan.** (Ind. Élect. 7. pp. 45–48, 1898.)—This is an account of experiments made in the laboratory of the Compagnie parisienne de l'Air Comprimé, in order to ascertain the effect of vibrations on the indications of Thomson meters, and the best means to overcome this. The meters tested were fixed against a thin partition, to which was also attached a trembling bell-movement, in order to give vibrations of constant frequency and amplitude.

In the absence of vibration, the meter follows the law $y=a+bx$; the effect of vibration is to displace the line parallel to itself, changing a from a negative towards a positive value, while b remains constant. When a, which depends on the starting current and friction of the mechanism, is negative, the meter does not begin to move until $x=-\frac{a}{b}$; when a is positive the meter runs without load, "on the shunt," which leads to dissatisfaction on the part of the consumers. To avoid this, it is usual to tighten the brushes, so as to give a such a large negative value that it never becomes positive under the action of vibration; but this leads to a considerable loss to the Supply Company, especially in the case of large meters, as the meter does not start unless the load reaches 1 or 2 per cent. of the maximum, and runs slow for small loads. The effect of this is illustrated by diagrams showing the percentage slowness at different loads for several values of a.

The method found to be most effective in shielding the meters from vibrations was that of mounting the meter on indiarubber buffers (*amortisseurs*), provided with brass caps for attachment to the meter and to a horizontal supporting bracket.

The method of testing and the apparatus used are described, and the following results given:—In a test of a 25 a. 110 v. meter,

the change in a without the buffers amounted to 12 watts; the use of buffers reduced the change to 1·77 watts. A similar test of an 11000 watt meter gave 44 watts and 2·4 watts without and with buffers respectively; the buffers in this case were thicker.

The author has found it possible in practice, with the use of buffers, to adjust large meters to start with 0·005 of their maximum capacity, without risk of running on the shunt. Further, the wear of pivots and sockets, and sparking at the brushes, are greatly reduced. A. H. A.

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314. *Automatic Cut-in Switch.* (Electn. 40. pp. 391–392, 1898.)—This is a description of an automatic switch for bringing extra transformers at sub-stations into action as the load increases. One transformer is always connected to the mains: to each of the others is attached one of these "Walton" switches. The principle is as follows:—Above the switch, and attached to it, is a heavy mass of metal which is held in position by an electromagnet device actuated by solenoids traversed by all, or a portion, of the current passing through the permanently-connected transformers. When this current exceeds a certain value, the heavy mass is released, and in falling drives home the switches necessary to bring a second transformer into action. The arrangement is such that the primary switch is not closed until after those belonging to the secondary circuit, thus avoiding a rush of current in the primary circuit. These switches are in use at the Bayswater sub-station of the Metropolitan Electric Supply Company. It is noticeable that the switch will not automatically cut out the transformer when the load falls. W. G. R.

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315. *Magnetic Cut-out.* **M. Aliamet.** (Électricien, 14. pp. 385–387, 1897.)—These cut-outs are operated briefly as follows, viz.:—The knife or other movable contacts are mounted on an arm which is acted upon by a spring so as to normally break the circuit. This arm is held in position to complete the circuit by means of a detent consisting of a hook on the arm engaging a hook on one end of a pivoted lever. The other end of this lever is acted upon by the core of an electromagnet in series with the circuit to be protected, so that, when the current exceeds a predetermined value, the hooks will be disengaged from each other and the circuit broken by the action of the spring above mentioned. C. K. F.

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316. *Schuckert Indicator for Broken Circuits.* **M. Aliamet.** (Électricien, 15. pp. 38–39, 1898.)—In polyphase installations it is necessary that the load and power-factor of the different phases should be equal. When the circuit of one of the phases is broken, there is a want of equilibrium in the distributing system, and there occurs an inadmissible fluctuation in the pressure of the other phases. The Schuckert device is for the purpose of indicating

when the circuit of one of the phases has been broken. It is based on the principle of the differential balance, already used on three-wire continuous-current circuits, in which case two solenoids having the same number of turns are connected across the two sides of the three-wire system. Into these solenoids dip two similar soft iron cores suspended from the arms of a balance. When the distributing system is out of balance, the attraction will be greater on one core than on the other, and the consequent tilting of the balance-beam constitutes a signal. In the Schuckert device, three laminated cores are used, quite similar to one another and fixed to the three corners of a triangular support suspended from its centre. The three electro-magnets are each connected in the circuits of the three phases, and any weakening of the current in any of the phases will cause the triangle to tilt, and a signal can be given by a system of electrical contacts. This device may also be employed in a two-phase system having a common return. In this case the solenoid connected in the return circuit should have $1{\cdot}414 = \sqrt{2}$ times less turns than for the other solenoids.

This device has been successfully employed in Germany.

L. J. S.

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317. *Montaux Multiphase Fire Cable.* (Elect. Rev. 42. p. 60, 1898.)—Among the devices common in the United States for automatically locating and announcing an outbreak of fire, thermostats are employed for automatically closing an electric circuit when the local temperature passes a certain point. These thermostats are scattered throughout a building in various places; and the disadvantage exists that, if the fire should start at a point intermediate between two thermostats, there would be more or less delay until the temperature reached the proper degree to operate the alarm. The above system of fire cable consists of the logical development of the usage of the thermostat; and instead of the use of a number of isolated instruments, the whole wire itself is so sensitive that the mere heat of a lighted match applied to any point of the wire will cause the metal to fuse and ring an alarm.

The cable is made up of an inner copper wire covered with a metal which fuses at the low temperature of 374°, the copper being used to increase the conductivity. The fusible metal is covered with a suitable insulation, and over this again is wrapped a series of smaller wires with insulation between them, the whole being covered with an outer protective wrapping. One of the outer wires serves for the fire alarm, another the burglar alarm, another may be used for the servants' call, and the remainder for various purposes. A fire in the neighbourhood of the wire will fuse and expand the inner fusible coating and force it through the insulation into contact with the overlying return wire, thus closing circuit and turning in an alarm.

A valuable feature of this cable is that it forms an effective burglar alarm; for if a burglar should attempt to destroy the ordinary window-alarm by breaking the window-glass and cutting

the wires. the pliers will form a metallic connection between the inner and outer wires of the cable and close the circuit. To avoid error in connecting up the return wires, they are made in different colours.

Considering the complicated nature of the cable and the duty that it performs, its bulk is said to be remarkably small and attracts no more attention than ordinary house-wiring. For detecting a fire, due to spontaneous combustion in the coal-bunkers or hold of a ship, the wires are laid in pipes which protect them from rough usage but leave them exposed to the action of heat. An important feature in the utility of this cable is the rapidity of its action upon the outbreak of a fire. L. J. S.

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318. *Electrical Cooking.* **J. P. Jackson.** (Amer. Instit. Elect. Engin. 14. pp. 397–402, 1897.)—The tests of electrical cooking apparatus detailed in this paper were made with the hope of obtaining a method of cooking that would be satisfactory, with a minimum risk of fire, in a college which is supplied with electricity for lighting and power at a pressure of 110 volts. Experiments were carried out with the following apparatus :—

1 oven, $13'' \times 9'' \times 18''$, having 3 heats, of 3, 10, and 17 amperes respectively;
3 stoves, of 2, 4, and 5 amperes respectively;
2 flat-irons, of 1·5 and 6 amperes capacity;
1 broiler, of 12 amperes capacity;
1 curling-iron, of $\frac{1}{2}$ ampere capacity.

In all these appliances the heating-coils are so arranged that the energy is largely concentrated at useful points. They are also supplied with supports and bases which are poor conductors of heat.

The efficiencies of the two larger stoves were obtained by heating two pounds of water to the boiling-point and measuring the power supplied by a calibrated wattmeter. The efficiencies, considering the ratio between the amount of heat absorbed by the water and the amount received by the stoves, were :—

For the larger, or No. 1	48·9 per cent.
For the next size, No. 2	43·1 ,,

When it is desired to boil water, the best plan is to place an immersion-coil in a properly heat-insulated pot; such an arrangement should give an efficiency of 90 to 100 per cent. The cooking apparatus was used for cooking meals for a family of six during several weeks. The following figures may be taken as a fair average of the whole period; all costs being estimated on a basis of 10 cents per kilowatt-hour :—

Breakfast	1·355 kilowatt-hours.	Cost, 11·46 cents.
Dinner	2·98 ,, ,,	Cost, 29·8 ,,
Supper	8·39 ,, ,,	Cost, 8·39 ,,

The author then states the energy required for different kinds of

foods; such as bread, meat, soup, etc. The result of a whole series of meals was a cost for electricity of 13·1 cents per meal. When the meals were cooked by means of coal burnt in a stove (No. 8, Othello coal stove), the results gave an average of 12·6 lbs. per meal, which at 5·00 dollars per ton gives a cost of 3·15 cents per meal, showing the cost of cooking by coal to be about 19 per cent. of the cost of cooking by electricity.

The author also gives data relating to the cost of ironing by electricity.

The results of the cooking tests seem to indicate that, for the usual cooking of a family for the whole year, the expense would be larger than would be ordinarily acceptable notwithstanding the great advantages in other respects. The author considers that in a number of cases the utility of electrical cooking utensils should be great; for instance:—

(1) For light housekeeping, where coal, oil, gas, or gasoline are frequently used;

(2) An electrical stove of 300 to 400 watts, to replace the frequently-used alcohol flame;

(3) In the shop the glue-pot, solder-pot, brazing-iron, etc. can be heated advantageously by electricity.

Other cases are also mentioned.

The general results of the tests were of such a nature that the writer is warranted in the belief that if Central Station managers would more generally introduce such applications, a new call on their station capacity would develop, of which a large proportion would be during the light-load periods. L. J. S.

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319. *Enormous Electric Beacon.* (Elect. World, 31. pp. 96–97, 1898.)—There is at the United States lighthouse establishment at Tompkinsville, Staten Island, a gigantic electric beacon. The lantern consists of two lenses, each 9 feet in diameter, enclosing between them an electric arc of great power. In the central portion of each lens is a disc having two prismatic rings. Outside this are 190 prismatic segments so arranged that the light of the arc is totally reflected in each and thrown out in a practically non-divergent beam. In this way nearly all the light of the arc, which is estimated at 90,000,000 candles, is concentrated in two great beams 9 feet in diameter, directed towards opposite points of the horizon. The beams of light could be seen at a distance of 100 miles if placed in a sufficiently high tower.

The whole apparatus is floated on mercury, and is rotated by a powerful clockwork arrangement. The period of one revolution is 10 seconds; so that every point of the horizon is illuminated once every 5 seconds. The weight of the complete apparatus is about 20 tons. The lamps are arranged to carry carbons of from 15 to 60 millimetres in diameter. With 30 mm. carbons the arc takes a current of 60 amperes at 55 volts on an alternating-current circuit of frequency 140 cycles per second. W. G. R.

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320. *Electric Grain Elevator.* **O. E. Dunlap.** (West. Electn. 22. pp. 62–63, 1898.)—The Great Northern R.R. Company's grain elevator is situated in Buffalo, N.Y., on the Blackwell Canal; the structure is 396 ft. long, 150 ft. wide, and 177 ft. high, and is built on a foundation of piles and masonry. There are sixty-six cylindrical steel bins, 85 and 60 ft. high, having a total capacity of 3,000,000 bushels. The building is equipped with ten inside legs 177 ft. high, each driven by a 50 horse-power motor, and carrying two rows of buckets; each leg handles 15,000 bushels of grain per hour. A 100 horse-power motor is used for driving fans and dust-collectors. Two conveyor belts, each 60 ins. wide, 740 ft. long, are driven by two 20 horse-power motors, and have a capacity of 40,000 bushels per hour each. Between the elevator and the canal are two railroad tracks on which run three marine towers, each having 32 wheels. Each tower carries a 100 horse-power motor, and is capable of elevating 20,000 bushels per hour; electrical energy is supplied by means of three trolley-wires 40 ft. from the ground. The towers are moved by means of a cable driven by a 50 horse-power motor within the building There are two railroad tracks on the north side of the building, and one within the latter; from these 400 cars can be shipped daily. The electrical energy is derived from Niagara Falls, at a distance of 30 miles; the generators, of 5000 horse-power each, supply current at 2200 volts, which is transformed up to 11000 volts and transmitted through six cables on the three-phase system. At Buffalo the pressure is reduced to 2200 volts in a transforming station, and again to 440 volts at the Great Northern elevator by means of two 600 horse-power transformers. The current is received as three-phase and used as two-phase. The main switchboard consists of nine panels, bearing the controlling apparatus for all the motors except those in the marine towers. The motors are of the Westinghouse induction type, six-pole, 440 volt, running at 500 revolutions per minute; they are without brushes, and therefore sparkless—an important feature on account of the presence of grain dust. Flexible cable, insulated with rubber, and supported by cleats, is used for the wiring. There are 420 lights, controlled from the ground floor, and from distributing boxes for groups of 10; these are on two-phase 104 volt circuits. The elevator was built by D. A. Robinson, under J. J. Hill, the President of the Great Northern R.R. Company, at a cost of about 500,000 dollars. A. H. A.

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321. *Volatile Oils in Boilers.* **W. H. Edgar.** (West. Electn. 22. pp. 63–64, 1898.)—In this paper the author points out that the action of kerosene and petroleum in cleansing boilers from scale is purely mechanical; the oil penetrates between the scale and the iron shell and loosens the former. On the other hand, it is decomposed in contact with the hot shell and carbonises the plates, causing blisters and roughening the skin of the iron. The

oil is volatile at moderate temperatures and passes with the steam into the pipes and engine cylinders, which it corrodes and blackens; it also injures joints and metallic packing.

In the discussion which followed the paper, the author stated that corrosion in the presence of pure water only is due to the formation of ferric hydrate; the action is less vigorous when the water contains salts of lime and magnesia. Crude tannin was highly recommended for preventing scale; tannin converts carbonates into tannates, but has no effect on sulphates. Pure tannic acid is too stable. Sugar is useful in converting sulphates into saccharates, which break up into other organic salts; a small quantity of slippery elm facilitates the reactions, as it contains soluble wood-starch, which makes the sugar and tannin less stable. The feed water should be analysed, and suitable proportions of sugar and tannin employed. These substances have no injurious effect on the boiler, steam-pipes, or packing. A. H. A.

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322. *Tests of Anthracite.* **J. L.** (Ind. Élect. 7. pp. 50–52, 1898.)—Some tests are given of English anthracite with Richards grates and of St. Charles coal. M. A. Laclance, prior to making the tests, experimented with Langer smoke-consumers and had six boilers fitted with them. The grates are formed by cast-iron plates perforated with conical holes. Under the plates are led jets of steam which create a forced draught to ensure complete combustion of the anthracite. St. Charles coal costs 28 francs a ton and anthracite 34 francs, including 7·2 francs duty and 3·5 for cartage. The mean of four tests of anthracite gives 7·787 centimes as the cost of energy per kilowatt-hour produced; and the mean of three tests of St. Charles coal with ordinary grates and smoke-consumers 7·382 centimes, or with Richards grates with a forced draught 7·458 centimes per kilowatt-hour. Anthracite is the cleaner and more satisfactory coal, and would be much used in Paris if the price could be reduced to 32 francs per ton, as may be the case on obtaining a direct service between Paris and Cardiff. W. G. R.

DYNAMOS, MOTORS, AND TRANSFORMERS.

323. *Three-Wire Dynamo.* **P. Girault.** (Écl. Électr. 14. pp. 204–208, 1898.)—This is a description of a three-wire dynamo to furnish 1400 amperes at 290 volts and at a speed of 300 revolutions per minute. The armature is drum-wound in parallel with a connector joining together the points of the winding, which are at the same potential. The winding consists of 400 bars of copper in slots round the periphery of the core, which is formed by circular sheet-iron stampings held together by insulated bolts. The winding is divided into two symmetrical parts relative to the mean point which corresponds to the neutral conductor in the distribution. W. G. R.

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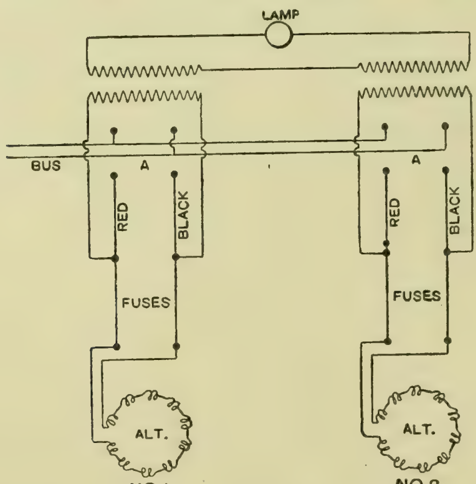
324. *Synchronising Alternators.* **H. E. M. Kensit.** (Electn. 40. pp. 478–479, 1898.)—The author gives methods of ascertaining whether, when running two alternators in parallel, the synchronising transformers are so connected that the alternators are in phase when the lamp is bright. There are three possible ways of connecting up the synchronising transformers: (1) each transformer with its primary across only one coil of the corresponding alternator; (2) each primary directly across the alternator terminals; and (3) one transformer primary across one alternator coil and the other primary direct across the other alternator terminals. Each of these three cases is discussed.—The second case,



which is the simplest and the best, is as follows:—The arrangement is shown diagrammatically in the above figure. Let AA represent double-pole switches for connecting the machines to the

bus, No. 1 the loaded machine, and No. 2 the incoming machine. Take out the fuses of No. 2, or raise the brushes at the alternator and insert the bus-plug at A. If, then, the lamp is bright all is right for paralleling. If not, the leads to the synchronising transformer of No. 2 must be reversed. W. G. R.

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325. *Paralleling Alternators.* **G. W. Meyer.** (Elect. Runds. 15. pp. 24–25, 1897.)—The method described by the author is more particularly applicable to small alternators, and involves very simple apparatus. Let one terminal of the alternator which is to be thrown into circuit be connected to one of the bus-bars, and let its other terminal be joined to the other bus-bar through a resistance, across a portion of which is placed a telephone receiver. If the alternators give identical wave-shapes, it is obvious that no sound will be heard in the telephone when the machines are running synchronously and are in phase with each another. When this condition is reached the resistance may be short-circuited by a switch, and the alternator thus thrown into parallel with the other machines. A telephone receiver may also be used in connection with a synchronising transformer. A. H.

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326. *Alternate Current Induction Motor.* **C. P. Steinmetz.** (Amer. Instit. Elect. Engin. 14. pp. 175–207 and 407–412, 1897.) —This treatment is supplementary to previous writings by the author on the same subject. Two new terms are introduced, viz.: "torque efficiency" and "apparent torque efficiency." Torque efficiency is defined to be the ratio of the torque of the motor to the torque which it would give at the same power input if there were no internal losses in the motor. Apparent torque efficiency is the ratio of the torque of the motor to the torque which it would give at the same volt-ampere input if there were neither internal losses nor phase displacement in the motor. These torque efficiencies are of special interest in starting where the power efficiencies are necessarily zero; and the author considers the names preferable to the terms "torque per watt" or "torque per volt-ampere."

The paper contains curves connecting the power output with (1) efficiency, (2) apparent efficiency, (3) current, (4) power factor, (5) speed; (6) torque for (*a*) the best motor built for 40 or 60 cycles, (*b*) a high-resistance motor, (*c*) a high-resistance and high-admittance motor, (*d*) a high reactance motor, and (*e*) a high susceptance motor. A comparison of these motors with each other shows that a good motor (*a*) is characterised by high values of power factor, efficiency, and apparent efficiency at light loads as well as heavy loads, by fairly close speed regulation and low exciting current. *High resistance* is characterised by poor speed regulation, and lowering of the efficiency at heavy loads; *high reactance* by very good speed regulation, good efficiency at heavy

loads, and low power factor and apparent efficiency at light loads; *high admittance* by high exciting current and poor power factor and apparent efficiency at light loads.

The author considers the effect of introducing additional resistance and reactance into the secondary windings, and concludes that by the use of additional resistance torque can be produced with the same current, power factor and torque efficiencies as correspond to the same torque when running; also the effect of additional negative reactance, or capacity, is to cause the torque and current of the motor to rise enormously. The question of an induction machine running with negative slip or acting as a generator is considered, and it is pointed out in the discussion that the same machine gives a considerably larger output electrically as a generator than it does mechanically as a motor.

The paper contains a useful reference table of the performances of three-phase and mono-phase induction motors. W. G. R.

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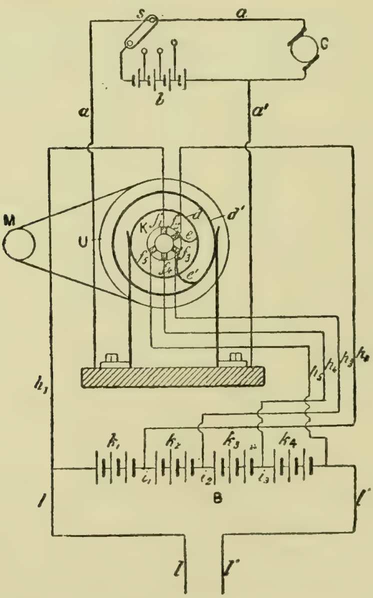
327. *The Transformation of Direct Currents.* **J. R.** (Écl. Électr. 13. pp. 558–559, 1897.)—This is a description of the Muller and Tudor commutator used in the transformation of continuous currents from low to high tension by means of accumulators. The arrangement is shown in the accompanying figure.



Muller and Tudor Commutator.

Two conductors a, a', between which is placed a battery of accumulators b, are fed from the generator G through the brushes C

and C′ of a commutator U whose collector-rings $d\,d'$ are rotated uniformly by a motor M. These rings have internal brushes which rub against the segments f_1, f_2, f_3, f_4, f_5 of the commutator K which are connected by the leads h_1, h_2, h_3, h_4, h_5 with a battery of accumulators B arranged in groups k_1, k_2, k_3, k_4, so that the leads h_1 and h_5 are connected to their extremities and the other three to the connectors i_1, i_2, i_3. The main leads from the battery are l and l' in the figure. By this arrangement it is seen that the battery B is charged in a parallel arrangement and discharged in series. The arrangement can evidently be adapted to a transformation from high to low tension in a similar manner.

W. G. R.

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328. *Electrolytic Rectifiers.* **J. Blondin.** (Écl. Électr. 14. pp. 293–298, 1898.)—In a discussion on the Pollak-Grätz rectifier the author gives a *résumé* of what had previously been done in this direction by other investigators as follows, viz.:—(1) The phenomenon on which these apparatus are based was discovered in 1857 by Buff (Ann. de Liebig, 52. p. 296, 1857), and rediscovered in 1875 by Ducretet (Comptes Rendus, 80. p. 280, 1874; Journal de Physique, 4. p. 84, 1875).—(2) The industrial application of cells with aluminium plates was first made by Ducretet for telegraphy; their application to the rectification of alternate currents was described for the first time by Hutin and Leblanc ('Étude sur les Courants Alternatifs et leurs applications industrielles,' 2nd part, chap. 10. p. 135, and French patent No. 215945, 1891). The apparatus has been studied from the theoretical side by Beetz (Wied. Ann. 2. p. 94, 1877) and Streintz (Wied. Ann. 32. p. 116, 1887; and 34. p. 751, 1888). C. K. F.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

329. *Electricity in Municipal Engineering.* **R. B. Owens.** (Elect. World, 31. pp. 151–152, 1898.)—The author points out the economy to be effected by generating the power required for various municipal undertakings at one point, and distributing it by electrical means. In many places the supply of water is obtained from wells by means of isolated steam-pumping plants; the latter may be replaced by pumps driven by electromotors, electrical energy being supplied from a central generating station. If storage reservoirs are provided, the load may be regulated, so that during the daytime the pumps absorb most of the output of the station, while at night the pumps are stopped and the whole output is available for electric lighting. Sewage disinfection by the Hermite or Woolf process may be carried on and regulated in the same way, so that the load on the generating station is practically constant over the twenty-four hours, and the load-factor of the plant approaches unity. This condition is highly favourable to the utilisation of the heat-energy of town refuse, which must be burnt at a very regular rate; this process may therefore be profitably combined with those already mentioned. A. H. A.

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330. *The Tendency of Central Station Development.* (Elect. World, 30. pp. 673–674, 703–704, & p. 759, 1897.)—These articles describe the developments which have taken place in recent years in the equipment and management of electric central stations. Ten years ago the only two systems of distribution were the continuous-current low-pressure distribution and the high-pressure single-phase alternating-current system with its multiplicity of small house-to-house transformers. The continuous-current system was used where the area of supply was compact, and the alternating-current system for straggling districts. The chief objection to the former is the high price of land and buildings for the station in a densely populated district, and the latter is open to objection on account of the small all-day efficiency of the plant. The consequence is a tendency to generate the power in each case at some distance from the centre of distribution where land is cheap; to transmit at high pressure to sub-stations, where it is transformed by means of large stationary transformers if the supply is to be alternating, or by transformers and rotary converters if a continuous-current supply is desired. The distribution is effected from the sub-stations by means of a low-tension network of conductors. In the central station itself small high-speed dynamos are, for economical reasons,

being replaced by larger low-speed machines, and belt-driven machines are giving way to those coupled direct to the driving engine, so that the latest developments are in favour of the slow-speed direct-coupled dynamos for either railway work, direct-current lighting, or alternating-current work. The development of the low-speed dynamo has been effected by increasing the diameter of the rotating part and by reducing the peripheral speed; thus reducing the iron losses and enabling the induction in the iron to be carried much higher without impairing the efficiency of the machine. A great help in the same direction has been obtained by the use of slot and tunnel armatures in place of smooth-core types, and the consequent permissible diminution of the air-gap.

The types of alternator most generally used now are inductor machines and machines with revolving fields, it being a great advantage to have high-pressure armatures which are stationary and free from mechanical strain. The disadvantage of aiming at a low first cost in erecting a central station is now more recognised, since the poorer the quality of the installation the more attention does it require and the greater are the running expenses and also the annual depreciation; and, as in all other trades, everything which contributes to the minimising of manual labour is now being advocated. W. G. R.

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331. *The Cost of Steam-Power.* **H. A. Foster.** (Amer. Instit. Elect. Engin. 14. pp. 315–345 and 461–470, 1897.)—This is a paper containing details collected by the author on the cost per horse-power hour of steam-power The plants on which tests were made were:—

Two Electric Lighting Stations;
One Grain Elevator;
Three Water-Works Pumping Stations;
Two Flouring Mills;
Six Cotton Mills;
Four Newspaper and Printing Offices;

and four others.

The items included in the cost of production are Fuel; Wages, Supplies; Repairs; Water; Incidentals, including lighting and removal of ashes; and also the fixed charges, Interest on cost of plant, Depreciation on the value of the plant, Insurance, and Taxes. When the cost of an item depends on the locality it is reduced to a certain standard in order to give a fair comparison. In estimating the cost per hour care is taken to reckon only the hours of actual working of the plant. In this way it is estimated that the cost of steam-power per horse-power hour is 0·00824 dollar for an average of 3080 hours. Below is given a table of comparison of this result with those obtained by others.

Comparison of Different Estimates.

Large, Compound Condensing Engines.

	Cost per H.P. hour.
Emery (for 3080 hours)	$·00784
Emery (for 7090 hours)	·00617
Emery (for 3080 hours)	·00856
Webber, 650 H.P. 3080 hours	·00720
Webber, 1050 H.P. 3080 hours	·00646
Hale, 2985 hours	·00557
Main, 3080 hours	·00637
Foster, average, 3080 hours	·00824

The average of all these estimates indicates that the cost per horse-power hour is about $0·00705 or 0·3525 of a penny.

W. G. R.

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332. *Electric Plant of U.S.A. Government Printing Office.* (Elect. World, 31. pp. 94–95 and pp. 115–118, 1898.)—In this very detailed description of the electric plant of the Government printing office at Washington, the great advantages of electric power over steam-power for driving machinery in factories is brought forward. Every piece of machinery in the place is now driven by motors, generally by direct couplings so that the inconvenience of running-belts is avoided. The following table shows the number of motors and the horse-power at present in use :—

	No. of Motors.	Horse-Power.
Crocker-Wheeler motors geared to printing-presses	85	272
Crocker-Wheeler motors keyed to shaft of printing-presses	7	35
Crocker-Wheeler motors direct-coupled to machinery	56	78
Crocker-Wheeler motors belted	14	144
Lundell motors keyed to shaft of presses	2	10
Bullock motors keyed to shaft of presses	2	10
Sprague elevator tandem drum	1	30
Total in daily use at present	167	579

The chief electrician states that the entire power necessary to do all the work of the office at night, including the running of the large web-presses on which the 'Congressional Record' is printed, did not amount, before the introduction of the electric motors, to within 15 or 20 per cent. of the friction load of the press-room engine and shafting. This shows at once one of the great advantages of the electrical transmission over the old belt system. All the motors are supplied with cut-outs, as fuses are regarded as unreliable and dangerous. On one occasion one of the press-men

accidentally had his hand caught in the gearing of the press; the load was raised above the normal, the cut-out acted, and his hand was saved. Had a fuse been used instead of a cut-out he would probably have lost his hand. The motors are all controlled by Crocker-Wheeler controllers. W. G. R.

333. *Electrical Shop Transmission.* **H. G. Dimick.** (West. Electn. 22. pp. 64–65, 1898.)—This article deals with the leading features of electrical transmission of energy in workshops, on the direct-current system at low pressure. The use of electromotors driving line-shafting is recommended rather than separate motors direct-coupled to the machines, unless the latter require more than 5 horse-power each; the generators should be large units, with a reserve, but a small unit should be provided for times of very light load. The apparatus required on the main and distributing switch-boards is briefly described, and the type of distributing cables to be used is considered. Automatic starting rheostats, which return to the starting position with all resistance in the armature circuit, whenever the current ceases to flow or exceeds a safe limit, are regarded as indispensable, and are discussed at some length. The margin of motor capacity to be allowed under given conditions is also considered. A. H. A.

334. *Transformer Distribution.* (Elect. Runds. 15. pp. 40–42, 1897.)—In spite of their extremely high efficiency at full-load, transformers show a poor all-day efficiency when permanently connected across the mains. Central station experience shows that the total energy delivered by a transformer during 24 hours is approximately equal to the energy delivered by it when worked for two hours at full-load. On this assumption the all-day efficiencies and other data of transformers of different outputs are given by the following table:—

Output of transformer in kilo-watts.	Useful energy in kilowatt-hours.	Iron losses in kilowatt-hours.	Copper losses.	Meter losses.	Total energy absorbed.	All-day efficiency.
10	20	3·52	·31	·864	26·694	·75
5	10	3·72	·17	·576	14·466	·692
2·5	5	2·28	·09	·288	7·658	·652
1	2	1·56	·04	·288	3·888	·515

It has been found by Herr Schlatter that when equal numbers of the above four types of transformers were connected across a

distributing network, the mean all-day efficiency came out at ·652, which is in accordance with the assuption made above. In order to improve the all-day efficiency, the house-transformer system has been abandoned, and the transformer sub-station system introduced instead; the number of transformers being thereby reduced and their size increased. In order to reduce the losses to their smallest possible extent, it is necessary to keep only as many transformers in circuit as will enable them to work at or near their full-load. Instead of completely switching them off, Herr Schlatter has devised an automatic switch by means of which an auxiliary transformer whose primary and secondary are joined in series with those of the large transformer is thrown into circuit when there is no secondary load, and absorbs the greater part of the losses on open circuit, thereby reducing them by 95 $^0/_0$. The Schlatter switch has already been described in these Abstracts (see No. 196, Feb. 1898). A. H.

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335. *The Saving Effected by Large Transformers.* (Elect. Engr. N.Y. 25. pp. 58-59, 1898.)—The distinct economy of using a few large transformers instead of many small ones is here shown by details of plants in which a change from the latter to the former has been effected. In a town in Massachusetts, 57 small transformers have been replaced by 18 larger ones of the latest type. The total core loss of the small ones which supplied 1499 lights was 5866 watts, whereas the large ones supply 1624 lights with a total core loss of only 1348 watts. This is equivalent to saying that the yearly saving of energy is 39,578 kilowatt-hours, or a saving per light capacity per year of 36·2 cents. Other instances are cited to show that where small transformers are installed it is a good commercial investment to replace them by as few larger ones as will meet the requirements of the particular plant.

W. G. R.

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336. *Electric Railways.* **G. W. Meyer.** (Elect. Runds. 15. pp. 50–54, 1897; id. 15. pp. 60–63, 1898.)—The author discusses the various methods available for supplying power electrically to trams or railway-locomotives. He advocates the use, for long lines, of the combination of a triphase alternate-current system with a continuous-current system and accumulators. In the power-station high tension triphase alternate currents are generated, and these currents are transmitted to transformer-stations in the neighbourhood of the railway. The transformers consist of drehstrom motors coupled directly to continuous-current generators which supply the current for the continuous-current motors on the cars. In the transformer-stations, accumulators can be connected in parallel with the continuous-current generators, these protecting the machinery and considerably increasing the profits of the plant. This system is due to Herr Uppenborn, and has been introduced at Cassel and Budapest (Elektrotechn. Zeitschr 1893 & 1894). A somewhat similar system, due to Herr Déri

is referred to in which transportable transformers and accumulators are employed. The high-tension triphase-currents are transformed down to lower-potential alternate currents which are supplied to overhead conductors along the line. The cars, etc. are provided both with drehstrom and continuous-current motors. The drehstrom motors are connected to the drehstrom conductors (2 wires, 1 earth) by the usual sliding or rolling contacts; whilst the continuous-current motors, which can also act as generators, are connected to a portable accumulator-battery in the vehicle. The continuous and alternate-current motors are only connected mechanically. The operation is as follows, viz.:—During the normal propulsion of the vehicle, the alternate-current motors drive, any excess energy being stored in the accumulators by means of the continuous-current machines. On gradients, where the alternate current is not sufficient for driving the vehicle, the accumulator-battery discharges into the continuous-current machines which now serve as motors. In parts of the line where it is not possible to supply current to the vehicle from the lines, the battery current alone serves for propulsion.

Various other systems of this kind are described and illustrated, viz.: that of R. Arno, in which a simple alternating current from the line drives an idle-running synchronous motor on the car, which motor, by the reaction of the alternate current generated in its armature on the alternating field, serves to produce a resultant rotary field of constant strength as in polyphase motors. This field replaces the rotary magnet-pole of a polyphase generator. Therefore, by arranging coils as in these generators, a two- or three-phase current can be obtained. The stationary part of the synchronous motor is thus, at the same time, the field for the production of the rotary field, and the armature for the polyphase current produced. The said polyphase current serves for driving one or more asynchronous motors geared to the driving-wheels of the vehicle. This system is, however, expensive and complicated. A somewhat similar system due to the Union-Elektrizitäts-Gesellschaft is also described, but this is open to the same objections as that previously indicated.

The systems of C. F. Scott and others having been described, the author ends by stating that continuous currents should be used for short lines; for longer lines the drehstrom-continuous current transformer system, or Déri's, or, where this also is impossible, the simple alternate current converted into a polyphase current (drehstrom). He also recommends an electrolytically-rectified (Pollak-Graetz) or mechanically-rectified alternate-current system in combination with stationary or portable accumulators.

C. K. F.

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337. *Electric Locomotive.* (Elect. Runds. 15. pp. 79–81, 1898.) —The article contains an illustrated description of an electric locomotive for shunting purposes, built by the Allgemeine Elektrizitäts-Gesellschaft of Berlin. A. H.

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338. *Electric Railway of the* 1900 *Exhibition at Paris.* **J. Reyval.** (Écl. Électr. 4. pp. 191–204, 1898.)—Although the conditions laid down by the Commissioners in their specification for the Electric Railway for the Paris Exhibition are somewhat severe, five competitors submitted schemes for the carrying out of the project. Of these schemes, that of Blot, Guyenet and Mocomble is the most interesting and attractive. Taking the idea from the railway at the Chicago Exhibition, they propose having the carriages fixed to the platforms, while the latter are themselves movable. Their system includes the following:—

First. A first platform moving at the rate of 10 kilometres an hour, having a breadth of 1·3 metres, and rolling on rails 90 centimetres apart.

Second. A second platform moving at a rate of 5 kilometres an hour, having a breadth of 80 centimetres, and rolling on rails 45 centimetres apart, and serving as a terminus.

Third. A fixed platform 90 centimetres broad.

Fourth. A metallic foot-bridge supported by columns and serving to support the rails.

Fifth. A staircase serving as an entrance and an exit for the passengers.

The platform which moves at the rate of 5 kilometres an hour is to be placed between the fixed platform and that moving at the rate of 10 kilometres; and the whole railway will form a closed circuit about 4200 metres long.

The system of two movable platforms permits of a large number of people being rapidly carried: it is calculated that this particular railway will be able to carry 38,880 passengers an hour.

W. G. R.

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339. *Demeuse Surface Contact Traction System.* **E. Piérard.** (Électricien, 15. pp. 35–38, 1898.)—It is stated that this system is characterised by a great simplicity, strength, and relatively low cost. The system consists essentially of a number of metallic button contacts placed along the track, each contact being connected to an automatic distributor, contained in a simple square cast-iron box imbedded in concrete, fitted with a cover through which the contact passes and to which it is rigidly fixed. The distributor consists of an electromagnet with two bobbins, one wound with fine wire and the other with thick wire. The car carries a small battery of accumulators. When the switch is closed on the car, the connections are so arranged that the fine wire coil is momentarily magnetised by the accumulators, and attracts an armature consisting of a lever at the end of which are blocks of copper or carbon for making contact in an upper or lower fork of special construction. The moment the fine wire coil is magnetised the lever is raised; the lever breaks contact at the lower fork, thus breaking the shunt coil, but having at the same moment made contact at the top fork, and thus completed the motor-circuit and magnetised the thick wire coil. Under these conditions the motor

will start, and as the car runs along its slider will break circuit with the leaving contact, and the next contact will come into operation, and so on. The sliders have received special attention to obviate wear and noise, and consist of five to ten strips of steel 5 cm. high and 0·5 cm. thick separated 0·5 mm. to 1 cm. from one another by means of lead washers. The use of an independent distributor for each section of the track allows the cars to be run in either direction by simply reversing the armature connections of the motor. This system also allows cars to follow one another as close as is desired on the same track.

According to the inventor's estimate the equipment of a kilometre of single track would amount at Brussels to about 27,000 francs, and a kilometre of double track to 50,000 francs, which amounts are comparable to an overhead trolley system. The author suggests that by the use of a double row of contacts it would not be difficult to work on the three-phase system, each row of contacts corresponding to one phase and the rails to the third. This system would have the advantage of not disturbing telephone installations. L. J. S.

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340. *Rapid Electric Traction.* **C. H. Davis** and **F. S. Williamson.** (Eng. Mag. 14. pp. 32–55 & 253–266.)—The authors consider the possibility of travelling from Philadelphia to New York, a distance of 85 miles, in 36 minutes, involving a speed of 170 miles per hour. A third rail system is suggested with 11 high-tension generating stations along the line and 30 rotary-transformer sub-stations. The track should be rigid, with rails of about 250 lbs. per yard, so as to avoid the creation of destructive waves. To reduce oscillation one rail might be raised somewhat above the level of the other. On the sharpest curve (of 4 mile radius) the elevation of the outer rail would not exceed 3·5 inches. A system of automatic signalling is described such that the power is shut off when the signal is at danger, rendering it possible to run trains with a headway of 3 minutes. The proposed motor-cars are 150 tons in weight and are carried on two six-wheel bogie trucks.—In estimating the necessary tractive force, the authors assume that the lowest value so far observed for journal and rolling friction would not be exceeded. This would amount to 2·7 lbs. per ton for the car suggested. The greatest curve-resistance would be 1/9 lb. per ton. Atmospheric, oscillatory, and concussion resistances cannot be well computed for want of data: at high speeds the usual formulæ probably give a result much too high. The authors consider that a train of five cars will not require more than 10,000 H.P. at the station under economical conditions, the maximum being about fifty per cent. greater. The generating stations would have an economical capacity of 30,000 H.P., and the sub-stations 20,000 H.P.

The total cost of construction and equipment is estimated at £38,000,000. The expenses per car mile will probably closely approximate to present practice, for, while fuel and some other

items will be increased, the saving in the labour account will be far greater owing to the high speed and omission of local stations. A detailed estimate, by comparison with the expenses per car mile as obtained under ordinary steam railway-conditions, leads to the conclusion that the saving due to the proposed system would balance the additional expenses. The cost per train mile on a steam road may be taken as 2*s.* 6*d.*: or, considering a train of four cars, and regarding the locomotive as equivalent to one car, the cost per car mile under these circumstances amounts to 6*d.* Assuming the cost per car mile to be 7½*d.* (*i. e.* twenty-five per cent. greater than with steam), the total operating expenses for 500 trains per day (averaging 2·8 cars each) amounts to £1,303,050 per annum. The capital is put at £20,000,000 of three per cent. gold bonds running for 100 years; £20,000,000 of non-cumulative four per cent. stock and £20,000,000 common stock. The fixed charges would thus be £750,000. A four per cent. dividend on the preference amounts to £800,000. Assuming 73,000,000 passengers per annum at 10*d.*, the gross receipts amount to £2,920,000. Thus we have:—

Gross receipts	£2,920,000	$14,600,000	100 %
Operating expenses ..	1,303,050	6,515,250	44·6 %
Fixed charges	750,000	3,750,000	25·6 %
Profits	866,950	4,334,750	29·8 %

Judging by present traffic statistics, and taking into consideration that traffic is always increased by electric traction coupled with such a large reduction in the fare (viz., 1 to 10), it may be reasonably supposed that the number of passengers travelling would largely exceed the number here given, thus ensuring a financial success. W. R. C.

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341. *Electric Traction on Railways.* **F. J. Sprague.** (Eng. Mag. 14. pp. 752–757, 1898.)—The author continues the discussion of the application of the system of individual car equipment to railway service. Controlling devices, signalling systems, and automatic electric brakes are briefly touched on, and the use of local storage batteries having high rates of charge and discharge is recommended for equalising the load on the generators; these may be used in conjunction with rotary converters and multiphase transmission. The Buffalo Street Railway Company, paying for supply from Niagara on the basis of maximum demand, find the cost to be greater than that of steam power; this would probably not be the case if storage were made use of.

The conditions of passenger traffic on short and long lines respectively are essentially different; the former require a frequent service of trains, while the latter can only be profitably operated by means of heavy trains at long intervals; hence electric traction is well adapted for use on short lines, but is unsuitable for long distances. The capital cost of an electric railway exceeds that of a steam railway by the amount expended on the generating and

transforming stations; so that, unless the running costs are materially reduced or the traffic increased by the adoption of electric traction, no advantage is gained.

The author concludes that:—the construction and working of main line electric railways present no insuperable difficulties; urban and suburban railways and busy branch lines are especially suited to electric traction; individual car equipment is preferable in the above cases; the use of storage batteries is of great importance, and will be extended; and the use of water-power is not necessarily advantageous. A. H. A.

342. *Loss in Stoppages of Electric Cars.* **H. S. Hering.** (Amer. Electn. 9. pp. 286–287, 1897.)—As the result of tests, the author finds the difference between making a stop and start at a station and running past it varies from 75 to 100 watt-hours, depending upon the gradient and load. The average value under ordinary conditions for a partially loaded $7\frac{1}{2}$ ton car is 85 watt-hours. Assuming the cost of electrical energy to be 1 cent per kilowatt-hour, one stop would cost ·085 cent, and the cost of making one unnecessary stop on each trip for fifteen trips daily would amount to $4·67 per car per year, and for 100 cars $467 per year for the one extra stop per trip. About 74 per cent. of the total energy required for propulsion is expended in accelerating and lifting a car, showing that if only one half of the energy stored in a moving car could be saved, the saving would be very large. As much as 20 per cent. may generally be saved by careful driving; 10 per cent. might be easily effected. Taking the average performance in city running on a 10-mile, fifteen-car, fifteen trip road as 1300 watt-hours per car mile, a 10 per cent. saving amounts to $1067 per annum. A motor-man should use the brakes as little as possible and drift as much as possible. W. R. C.

343. *Electric Car Driving.* **W. Munroe.** (Amer. Electn. 9. pp. 320–321, 1897.)—The author calls attention to the waste of current caused by careless driving. In order to maintain schedule time, motor-men frequently rush the controller handle round at starting without stopping at intermediate points. A heavy current is consequently taken without any large decrease in the running time. Comparative runs made upon a line with, in the one case, an average good motor-man and, in the other case, the electrician's assistant handling the controller, showed a difference of 20 per cent. in the watt-hours in favour of the assistant. Waste is also caused by seeking to increase the speed by weakening the field in any case where the car cannot attain a reasonable speed; the method is all right on the level but not on a gradient, as only a low back-E.M.F. can result on the latter. It sometimes happens that motors heat more than would be expected, and armatures burn out just when there is heavy traffic and it is most inconvenient. This is often due to excessive lowering of the pressure

on certain parts of the line necessitating the use of abnormally large currents. To detect such parts of a road it is advisable to run a car with a voltmeter and ammeter upon it, taking frequent observations during the trip. W. R. C.

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344. *Sprague Multiple-Unit Traction System.* (Amer. Electn. 9. pp. 343–344, 1897.)—On July 26th, 1897, the first public exhibition was given of Mr. Frank J. Sprague's new multiple-unit electric railway system, a trial train of six 42 ft. elevated railway-cars being run over the tracks of the General Electric Co. of Schenectady, N.Y. The cars used are to form part of the equipment of the Chicago South Side Elevated Railway. The main idea of the Sprague system is that it provides means for the individualising of cars, and yet admits of their being concentrated in trains without detriment to either method of operation. Each car is complete as it runs, yet if half a dozen of them are thrown together they lock-step at once and the train operates as a unit. Each car at Schenectady was equipped with two G.-E. 57 motors rated at 50 H.P. each.—The Sprague controlling system is similar in some respects to that employed with the Sprague electric elevators, the controller being operated by means of a small pilot motor. The motor-man may control the train from either of the platforms of any one of the cars; the controllers on each car having simultaneous motion corresponding to each movement of the handle operated by the motor-man. Underneath each car runs a flexible cable equipped with a peculiar interlocking coupling so that, no matter what is the speed, any car can be almost instantly thrown in or detached, in the former case at once answering to the control of the train motor-man. At Schenectady additional cars were coupled to a train running at 25 miles per hour.—The system includes automatic devices similar to those on the Sprague electric elevators, whereby every contingency that may arise in operation is provided for, such as burnt-out motors, defects in motor controllers, breaking of any of the circuits, etc. The whole train of cars at Schenectady was run at 33 miles an hour, and then split up into various groups of its component parts, making again the same rate of speed. The passengers on board gave an approximation to the normal conditions of an ordinary train load. Each car had air-brakes and an automatic air-compressor, circuit-breaker and electric lights, all drawing their supply from the main-line circuit, which in this instance was carried by an outer rail.

The important points in the Sprague system are the subdivision of traffic of which it admits, and a maximum tractive power which enables a maximum accelerating effect to be obtained. About 58 per cent. of the weight of the train and its load is available for traction, and the weight is moreover distributed in an ideal manner over the rails. There is, further, a saving of time to passengers in running a single car in light hours. L. J. S.

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345. *Single-Motor Cars.* (Amer. Electn. 9. pp. 360–361, 1897.) —The author discusses the cases where a single equipment is much superior to a double one. This is specially so in the case of interurban service. The series-parallel controller with its two motors may be said to have practically displaced the single equipment for street railway-work. On long interurban lines, where but few stops are made, there is practically but one speed, and a single running-notch suffices, although single equipments have been made with two and sometimes three running-notches. A single equipment will take less current than a double equipment of the same capacity, owing to the fact that one large motor has a higher efficiency than two small ones. Further, in the case of a double equipment it is very rare that the motors act together: one is almost certain to take more current than the other, and it is easily possible for one motor to be heavily overloaded and the other lightly loaded. Apart from these poor efficiency conditions, the power wasted in skidding of the wheels greatly detracts from the output of the double equipment in miles per kilowatt-hour, and gives the single equipment another point of vantage. A good illustration of how a single equipment can do more work in proportion than a double one often obtains in the case of hill climbing. The chief objection to a single equipment is the uneconomical variation of speed, and with the most usual conditions under which a street railway works it is an insurmountable one. The control is simply a rheostat in series with the motor, and unless the rheostat is heavily built with thick wire this provides but one running-notch, for the reason that if the rheostat is not immediately cut out it will overheat. A second running-notch can be provided by feeding the current into the motor at some point in the field-winding. Usually this place cuts out about half of the winding, thus weakening the field and increasing the speed of the motor. The speed is also increased owing to the fact that the drop over the field magnets is lower, and consequently the voltage across the armature is greater. The usual methods of connecting a single equipment is to utilise a portion of the contacts of a series-parallel controller; it is, however, not economical to do so, for the reason that the same thing can be accomplished with a much less expensive device. An illustration is given of the T-H method of connecting a single equipment and the connections thereof. The old Sprague method of controlling a motor by the commutated-field device—that is, a subdivision of the field-coils into sections, and the excitation of these sections by connecting them in series or multiple with one another—provides a great many more running-notches; but the difference in speed between these notches is not so marked as to make it worth while to employ the method, except in special cases. The motor-man who is running a single equipment should learn the art of drifting where a reduced speed has to be maintained; this is accomplished, when rheostatic control is used, by turning the full power on for an interval and, as soon as the car has gained headway, cutting it

off altogether and allowing the car to drift along. The car should be drifted as much as possible, and the brake used as little as possible. L. J. S.

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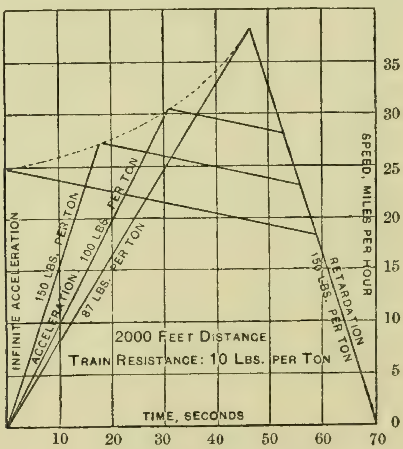
346. *Electric Traction.* (Amer. Instit. Elect. Engin. 14. pp. 453–460, 1897.)—This is a discussion upon a paper by **Gerry. Dr. Perrine** called attention to the importance of rapid acceleration in train service. The **President** said that electricity afforded a means of running trains at always the same headway, thus giving a more popular service, the periods of light load being met by the use of shorter (not less frequent) trains. **Prof. Thomson** remarked that although it was desirable to apply the power to motors on every car, it was questionable whether the gain was sufficient to warrant the increased outlay and the use of complicated mechanism.

Mr. Steinmetz gave some interesting figures with regard to the elevated railroad. Here, the distances between stations being short, the motors never run at full speed; each run consisting of acceleration and retardation. The case is considered of a 2000 feet run in 70 sec. The train-resistance being taken as 10 lbs. per ton, the accelerating-effort as 100 lbs. per ton, and



braking-effort as 150 lbs. per ton, a curve is obtained, shown in the figure. The train accelerates for 31 sec., reaching a maximum speed of 30·5 miles per hour; it then coasts, the power being turned off, up to $52\frac{1}{2}$ sec. after the start, after which point the brakes are applied until the train is brought to rest. The lowest acceleration at which the distance can be covered in schedule time is 87 lbs. per ton. With this value, as seen by the curve, there are only periods of acceleration and braking, the maximum speed rising to 38·2 miles per hour. The more rapid the acceleration, the shorter is the time required for accelerating, leaving more for

coasting, and at the same time the maximum speed decreases to 30·5 miles at 100 lbs. acceleration, 27·2 miles at 150 lbs., and 24·8 miles in the theoretical case of infinite acceleration—*i. e.*, if the train could be brought up to maximum speed instantly. These figures have an interesting bearing upon the energy consumed. With change of acceleration the speed varies from 24·8 to 38·2 miles per hour—*i. e.* in the proportion of 1 to 1·54, and consequently the kinetic energy in the proportion of 1 to 2·4. The energy put into the train for acceleration varies even more, because at the lower acceleration the time of acceleration is greater, and thus the friction loss during that time is also greater. Since the energy put into the train, up to the point of maximum speed, equals the total energy required to cover the distance in schedule time, it follows that by varying the rate of acceleration the energy consumed can be varied in the ratio of 1 to more than 2·4 ; thus with the slowest possible acceleration more than 2½ times as much energy is required than would be necessary at infinitely rapid acceleration—*i. e.* the greater the acceleration the less energy required to cover the distance in schedule time, but the power absorbed by the motors is larger during the time they are in operation.

A lower maximum speed may be employed with a given acceleration and retardation by running partly at constant speed, but the efficiency is considerably less than when coasting is taken advantage of, as may be seen thus :—The total input of energy is equal to that consumed by the brakes plus that consumed by friction. The latter is the same in any case, but the former is less in the case of coasting, the brakes being applied at a lower speed than when running at constant speed. Thus it is theoretically (also practically) uneconomical to leave the motor in circuit after the period of acceleration has passed.

During the whole time of constant acceleration, part of the voltage is consumed in the rheostat, since without a rheostat a series motor does not maintain constant torque at constant voltage with varying speed. Such loss may be partly reduced by cutting out the rheostat somewhat before the maximum speed is reached, and allowing the motor to accelerate with an effort decreasing with the speed, as indicated by the dotted curve in the figure. The permissible range, however, is very short.

With regard to subdivision of motors, Mr. Steinmetz did not think it necessary to have all axles driving. The limit of permissible acceleration is not determined by the adhesion of the wheels, but by the comfort of the passengers. W. R. C.

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347. *Electric Traction.* **C. Marshall.** (Elect. World, 30. pp. 760–761, 1897.)—The author deals generally with electric traction, and enumerates the advantages likely to follow by its adoption on present steam roads. The coal consumption in locomotives varies from 3½ to 10 lbs. per H.P. hour, which allows a

large saving to be effected by the use of electricity generated at suitably placed central stations. A change to electric traction also generally means a large increase in traffic, as on the Berlin and Hartford (U.S.A.) line, where the increase amounted to 400 per cent. The greatest difficulty lies in the comparatively low voltage that must be employed, and consequent large expenditure of copper. According to Stillwell it costs 400 times as much copper to transmit a horse-power ten miles at 500 volts as it does at 10,000 volts. W. R. C.

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348. *Overhead Trolley Construction.* (Electn. 40. p. 379, 1898.) —A short illustrated account is given of the "Wood" type of frog for crossings and turn-outs. The flanges of the trolley-wheel are guided in the desired direction by grooves cut in the lower surface of the frog; in some cases a movable point is provided similar to that on the rails. These frogs are in use on the Bristol electric tramways. A. H. A.

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349. *The Rouen Electrical Installation.* **J. Reyval.** (Écl. Électr. 13. pp. 585–589, 1897.)—The first electric plant at Rouen was installed in 1880 to light the quays. The increasing demand for artificial light has resulted in the erection of a large and well-equipped central station for the generation and distribution of electrical energy by both continuous and alternating currents. To meet the requirements of the consumers, three groups of dynamos have been installed:—First, two pairs of Brown dynamos giving 1200 amperes each at 120 volts, which are coupled two and two in series to distribute at 240 volts. Second, two Thury dynamos driven by a 1000 horse-power Carel engine: these dynamos have ten poles and have carbon brushes, their normal output being 2050 amperes at 125 volts, and when coupled in series provide current at 250 volts for distribution; another similar group is shortly to be installed. Third, four Alioth converters, each coupled to a Willans machine. These converters have a double armature winding, and can furnish simultaneously continuous and alternating current or convert continuous current into alternating current, or *vice versa.* The alternating current is transmitted by underground cables at 2000 volts and distributed by overhead wires at 180 volts. The distribution of the continuous currents is also effected by overhead wires. The starting current for the converters is supplied by accumulators. In connection with the central station is a laboratory for the calibration and adjustment of electricity meters; the regulation and cleaning of the public arc-lamps; the measurement of the candle-powers and efficiencies of incandescent lamps; and for performing all electrical measurements likely to arise in connection with a central station.

W. G. R.

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350. *The Price of Electrical Energy.* **G. Claude.** (Écl. Électr. 14. pp. 93–99, 1898.)—This is a paper on sliding scales in the price of electrical energy, particular attention being given to the Brown and Routin system. It is pointed out that it is unfair to charge the same per kilowatt-hour at all times and to everybody, and that the charges should be made with certain stated objects in view. It is not so desirable that the maximum rate of consumption of energy should be great, as it is that the average rate should be high. The ratio of the average rate to the maximum rate of consumption is called the coefficient of consumption. Charges should therefore be made so as to entice consumers to increase their coefficient of consumption without, at the same time, necessarily increasing their maximum rate; also to tempt them to use more energy during the day, when the load on the central station is moderately light; and, further, to diminish the price according as the coefficient of consumption increases. Brown and Routin have endeavoured to attain these objects by charging at a higher rate in the evening than during the day, and this without using two meters. One meter is regulated by a clock arrangement, so that during certain hours of daylight its rate of registering is only half the rate during the remainder of the twenty-four hours for the same rate of consumption of energy. Being regulated by a clock, the control is automatic, and no separate circuit is required since that regulating device is worked by alternating currents when the current in the mains is continuous, and by continuous current when the supply is alternating. The regulating current can therefore be sent through the transmission-mains, and the controlling clock-work placed at the central station. W. G. R.

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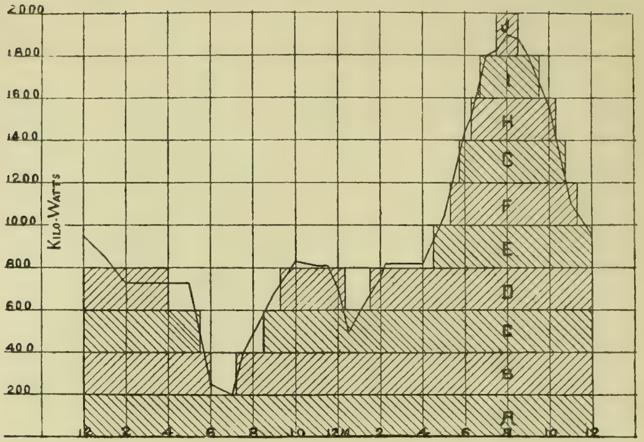
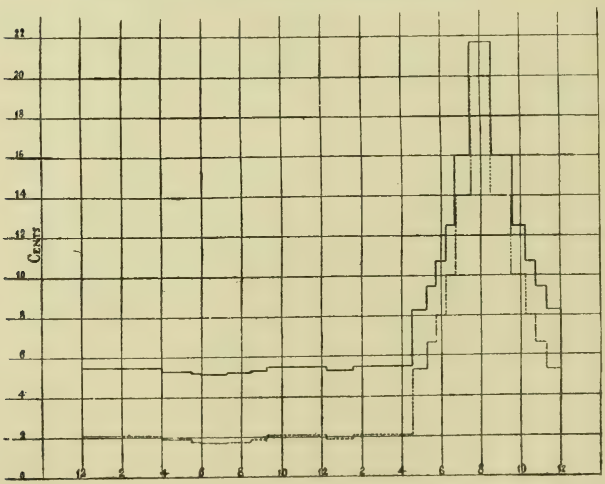
351. *Charging for Electrical Energy.* **W. S. Barstow.** (Elect. Engr. N.Y. 25. pp. 49–51, 1898.)—The author describes a system of charging depending on the load curve of the generating-station, which is intended to be simple and just, and to improve the load-factor by degrees. The cost of electrical energy is divided into operating and fixed expenses. The minimum load on the station is taken as a standard or unit load, and the average load-diagram is divided into blocks as A, B, C, &c. in Fig. 1, each equal in height to the unit load; the proportion of fixed expenses per day assigned to each unit of plant (of output equal to the unit load) is found by dividing the total fixed expenses per day by the ratio of the maximum load to the minimum load, and the fixed expenses per hour of each block are given by dividing this quotient by the length in hours of the block in question. The average value of the fixed expenses per unit load per hour at each hour is then plotted, as shown by the dotted line in Fig. 2. The quotient of the operating expenses per annum divided by the number of kilowatt-hours generated, corrected for the mechanical efficiency of the plant at different loads, gives the operating

Fig. 1.—Average load curve.



expenses per unit generated. This value, expressed in terms of the unit load for one hour, is added to the fixed expense per unit load per hour at each hour, giving the full line curve in Fig. 2 for the

Fig. 2.—Average expense curve.

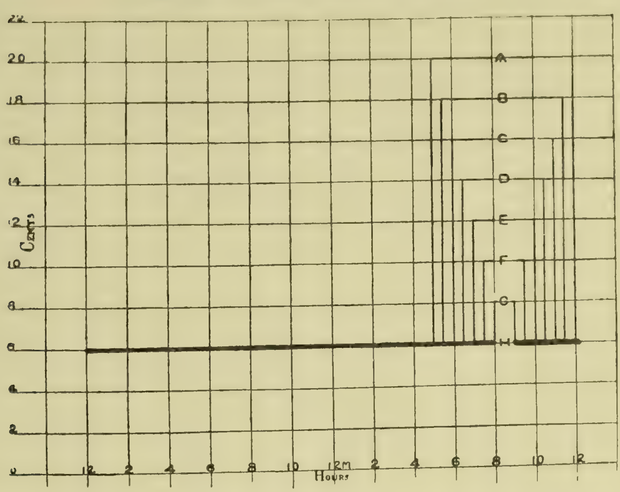


Dotted line shows fixed expenses. Solid line shows total expenses.

total expense per unit load per hour. It will be seen that as the load factor improves, the total expense line falls towards the level of the lowest total expense, or the low-cost period is lengthened,

and the high-cost period shortened. It is suggested that the day be divided into two parts, and that the average low rate be charged between the hours indicated by the curve; the effect of this is shown in Fig. 3. The Kapp meter device, in which a self-

Fig. 3.—TOTAL EXPENSE CURVE.



Effect on total expenses of increase of load factor; *i. e.*, A, load factor, 45 per cent.; B, load factor, 50 per cent.; C, load factor, 55 per cent.; H, load factor, 100 per cent.

winding clock is used, is recommended for the purpose of changing over from one meter to another, or for substituting one recording train for another, and *vice versa,* at the hours chosen; so that energy consumed during the time of light load may be charged for at a lower rate than that used during the time of heavy load.

A. H. A.

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352. *Multiple Rate Metering.* **E. Oxley.** (Elect. Engr. N. Y. 25. pp. 51–55, 1898.)—The importance of improving the form of the load curve of generating-stations is explained, and the method of effecting this object by charging a lower rate for energy during the period of light load than during the period of heavy load is advocated. Separate meters for the two periods, thrown into action at stated times by means of a clock mechanism, are objected to on the score of expense and want of reliability; the system of controlling the shunts of meters by means of a separate wire from the generating-station, so as to vary the speed of the meters, is also open to objection, since the drop of pressure in the controlling wire introduces errors, and the interruption of the wire would cause all the meters to stop. An apparatus is described for use with either two meters or one at each point supplied, by

means of which the differential rate may be applied, with direct control from the station. At each point a controlling switch is placed, actuated by two high resistance electromagnets; the connections of the latter are such, that upon earthing one or other of the mains at the station the corresponding electromagnet of each controller is energised, and throws a switch which either stops one meter and starts the other where two are used, or changes the resistance in the shunt circuit of a single meter so as to alter its speed. Diagrams of connections are given, and the method of application to chemical and other meters is explained. By using an earth-connection, a separate controlling-wire is rendered unnecessary, but apparently one or other of the mains is always earthed through the controlling switches. An accidental temporary earth on any part of the system might actuate all the controllers at the wrong time; to meet this objection, a device is described which automatically restores them to the correct position after such an event. A. H. A.

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353. *Relative Values of* 220 *and* 110-*Volt Lamps.* (Elect. Runds. 15. pp. 75–77, 1898.)—This is an abstract of a paper on the above subject by F. W. Willcox, recently published in 'The Electrical World of New York.' Considering the inferior efficiency of the 220-volt lamp, the author thinks that its advantages are frequently over-estimated. He states that the 220-volt lamps manufactured in the United States take 4 watts per candle as against 3·1 and 3·6 for 110-volt lamps. Hence, although there is a saving in copper by using a 220-volt system, the capital expenditure on the generating plant is increased. Under certain conditions, therefore, it would be better to use 110-volts. The author then considers in detail 110-volt two and three-wire systems as against 220-volt systems. A. H.

TELEGRAPHY AND TELEPHONY.

354. *Synchronograph Tests.* **A. C. Crehore** and **G. O. Squier.** (Elect. World N. Y. 31. pp. 145–147, 1898.)—This is an account of tests of the synchronograph on the English telegraph lines. The longest loop tried was 1097 miles, from London to Glasgow, Aberdeen, Edinburgh, and return to London by a different pole-line. The synchronograph was tried with a Wheatstone receiver, and it responded readily to each wave of current without any alteration of the receiver whatever. Using the synchronograph with the Wheatstone receiver appears to considerably increase the number of words which can be transmitted, the actual increase in any particular case depending upon the constants of the line. W. G. R.

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355. *Hertz Telegraphy.* **G. W. Selby.** (Electn. 40. pp. 397–398, 1898.)—A description is given of methods employed by the author during the past four years while experimenting with Hertz telegraphy. He follows closely on the early coherer work of Lodge. Carbon granules appear too sensitive to mechanical and acoustical disturbances for electrical coherers. The coherer preferred consists of a piece of hard fibre with a small hole bored through it, in which are fitted metal pole-pieces of silver wire. The best results are obtained with nickel and steel filings, with a trace of silver wire or mercury. R. A.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

APRIL 1898.

GENERAL PHYSICS.

356. *Specific Cohesion of Metals.* **R. Herzfeld.** (Annal. Phys. Chem. 62. pp. 450–453, 1897.)—Drops of various metals were prepared by making a piece of the metal the positive pole of an electric arc, on a carbon plate. The dimensions of the solidified drops gave the specific cohesions. The results showed that the specific cohesions of copper, iron, nickel, and cobalt are three times that of mercury, and they must therefore be classed in Quincke's third group. E. E. F.

357. *Sprengel Pumps and Röntgen Tubes.* **G. Guglielmo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 324–331, 1898.)—A paper on practical points as to construction of the above. A. D.

358. *Pump for delivering Liquids Air-free.* **P. de Sennevoy.** (Comptes Rendus, 126. pp. 224–225, 1898.)—The author describes and figures a pump which can conveniently be adapted to bottles, for the purpose of removing the contents of the bottle, as required, without allowing the inflow of air. R. A. L.

359. *Upper Atmosphere.* **L. Cailletet.** (Paris Soc. Franç. Phys., Bull. 108. pp. 4–5, 1898.)—Experiments are described for testing Laplace's law as to the density of the atmosphere at high elevations by sending, from balloons already at a considerable height, pilot balloons bearing automatic photographic apparatus. This apparatus photographs simultaneously, and at regular intervals, the face of a sensitive aneroid barometer and a view of the surface of the earth beneath. The latter being identified and distances on it measured, this gives the elevation. The other photograph

shows the simultaneous indication of the barometer. **M. A. Leduc** said, *à propos* of the above, he had recently found the air at 1650 metres above Paris contained the same amount of oxygen as the air in Paris, 0·232 (from 0·2318 to 0·2323). A. D.

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360. *Deformations on Stretching Metals.* **G. A. Faurie.** (Comptes Rendus, 126. pp. 400–401, 1898.)—A long rod of copper, for example, is softened by heating; it is then stretched with a force of 22 kg. per sq. mm.; the load is then removed. The hardening (" écrouissage de traction") is again removed by heat, etc. That is to say, the bar goes through the same cycle of operations again and again. After two or three cycles the rod develops an appearance resembling the nodes and ventral segments of a vibrating wire, equidistant swellings being separated by corresponding depressions. The author suggests that the phenomenon is due, in some way, to interference between the effects of the terminal clutches. A. Gs.

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361. *Determinations of Length by Interference.* **R. Benoit.** (Journ. de Physique, 7. pp. 57–68, 1898.)—With the help of the interference-bands of three cadmium lines (red, green, blue), Michelson in 1893 succeeded, in the laboratory of the Bureau International, to express the length of a metre in terms of wave-lengths. In the well-known apparatus, ray S is normal to mirror D, mirror A under 45° to AS; D′, the image of D in A, forms the plane of reference; C is parallel to D′ between A and D, and B, the compensator, parallel to A, intermediate between A and C. All the mirrors are plane; B can be turned about its horizontal axis. This arrangement is now used by Benoît for standardising millimetres and centimetres. Interference was produced by two of the several possible methods. In the one case, C and D′ are not quite parallel, when bands are observed; in the other, the distance CD′ is varied, when rings are noticed. For his determination, he used a polished nickel rule of 1 cm. divided in mm., and further a so-called Michelson standard, replacing Michelson's intermediate standard. A bar of bronze, 2 cm. square, 12 cm. long, has on its one end two steps, on which two four-sided glass prisms MM′ are standing, as nearly as possible 1 mm. apart. In measuring this distance accurately, the chief task is, after Michelson's work, to determine the " excédent fractionnaire " of the respective distance over a whole number of half-wave-lengths, that fraction showing which one of a series of determinations (115 were taken) of the different whole numbers with their different decimals is to be chosen. For this purpose, D′, M, M′ must all be parallel; D′ being larger than the other two, the plane of reference is projected simultaneously on both M and M′, and both show bands. Then follows the comparison of the MM′ distance as determined with the rule which is placed on the top of the bronze bar and viewed by a microscope (power 300). This microscope, the author

considers, is the chief source of error. Vacuum-tubes with a piece of cadmium, wrapped in copper, an induction-coil, and a carbon-bisulphide prism, gave the light. In addition to the three rays on which Michelson relied, Benoît also used a violet line for some of his experiments. The various determinations differ by $\pm 0{\cdot}006\,\mu$; the agreement with Michelson's values is slightly less perfect. The paper is illustrated by two small diagrams only. Chappuis is now determining the mass of a cubic decimetre of water by the Michelson-Fizeau method. H. B.

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362. *Bending of Thick Plates.* **Ribière.** (Comptes Rendus, 126. pp. 402–404, 1898.)—A mathematical treatment is given on the magnitude of the stresses in a *thick* plate, supported in various ways and subjected to a load. The results differ strikingly from those obtained by the usual method of treating a beam as consisting of longitudinal filaments to a large extent independent of one another. A. Gs.

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363. *A Photographic Impact-testing Machine.* **B. W. Dunn.** (Frank. Instit. Journ. 144. pp. 321–348, 1897; 145. pp. 36–47, 1898.)—The apparatus consists of an anvil, the cylindrical test-piece, a steel piston resting upon it, a mirror attached to the piston, a falling weight, a tuning-fork, and a revolving drum on which a magnified photographic record is obtained. The magnification depends upon the distance between mirror and drum. A hole is bored in the end of the tuning-fork, between which and the sensitised surface a lens is interposed, producing an image moving up and down on the drum which revolves about its vertical axis. By placing a fine wire in the path of the reflected ray, the band of two intersecting curves is broken up into dark and light horizontal strips. This novel arrangement admits of measuring a time-interval of $1/10^7$ sec. The small mirror turns about a fixed horizontal axis, and is connected with the piston by link-work. No further details are given concerning this important part, the mirror, which is to revolve at a rate depending entirely upon the rate of the piston.

The record-drum was first moved by an electric motor, which was, however, replaced by a system of cog-wheels and a weight of 100 lb. attached to a cord passing over a winding-drum. As high-frequency tuning-forks vibrate for a short period only, the following arrangement was adopted. The operator releases the 100 lb. weight, the photographic drum begins to spin, and the weight actuates a trigger, pulling a pin which allows the mass to fall. At the same moment an electric circuit is broken, and two shutters begin to drop. A few thousandths of a second before the mass strikes the piston, the photographic drum is disconnected from its gearing, and continues to revolve with uniform velocity; the wedge is pulled out of the tuning-fork. The mirror being as yet stationary, the sunlight (admitted through two pipes into the dark om)

traces an abscissa on the drum. When impact occurs, a brilliant line of light, almost vertical, is seen to flash up the drum; this line shows the compression of the copper test-block on first impact. There follow rebounds, and a wave of elastic compression preceding the permanent set. A mass of 33 lbs. falling through 15 in. produced a permanent compression of 0·1658 in. within 0·0030317 sec.; the rebound was about 0·002 in. It results that the dynamic curve which we really wish to determine when the behaviour of materials exposed to sudden blows is to be examined, differs little only from the static curve corresponding with a slowly applied force. Although Dunn's anvil is made of Harveyised nickel-steel, J. B. Johnson's objection that the yielding of the anvil would introduce errors seems well founded. H. B.

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364. *Method of obtaining Capillary Pores of specified Diameter.* **C. Barus.** (Phys. Rev. 6. pp. 52–54, 1898.)—A rubber tube, whose walls are $\frac{1}{32}''$ to $\frac{1}{8}''$ according as coarser or finer pores are wanted, is perforated radially with holes, disposed as nearly together as possible, from end to end of the tube. The puncturing is effected by a comb composed of about 50 equidistant cambric needles lying in the same plane, which is actuated by a mechanism similar to a screw copying-press; with this it is possible to pierce between 5000 and 10,000 holes per linear metre of the tube. After the needles are withdrawn, the holes close almost completely and are almost invisible to the unaided eye. A tube made radially porous in the above manner is a valve of a peculiar kind, so that if there is an excess of pressure on the inside the tube will enlarge, and the pores open proportionally. To use this device for obtaining pores of a specified diameter, the punctured tube is axially surrounded by a cylindrical wide glass tube. One end of the rubber tube is closed, and the other provided with a tubulure with stopcock and pressure-gauge for admitting gas (or turbid liquid to be strained) to the interior of the perforated tube. A similar tubulure is provided to the outer glass tube for water, as also an efflux tubulure. To calibrate this, it is necessary to allow gas to enter the perforated tube under pressure, and water the outer tube, and to observe the pressure excess of the gas gauge over the liquid gauge when bubbles first begin to appear. The author points out that if a perforated rubber tube be filled with water, and hung up closed at both ends in air, the water will gradually evaporate as through unglazed porcelain and the tube partially collapse, owing to the external pressure of the atmosphere. E. C. R.

LIGHT.

365. *Ultra-Violet Spark Spectra.* **F. Exner** and **E. Haschek.** (Wien. Akad. Sitzber. 106. pp. 336–356, 1897.) (For previous papers see Phys. Soc. Abstracts, 1896, No. 449, and 1897, Nos. 73, 301, 302, 526, 653.)—*Cobalt and Nickel.* It is remarkable that in the spectra of Co and Ni strong lines of equal or nearly equal intensity appear identically: *e.g.* line 3619·52 ($i=1$) appears in Ni, and line 3619·55 ($i=2$) appears in Co. Such coincidences are still more frequent in the weaker lines, as already shown by the measurements of Hasselberg, who also called attention to the fact that the lines of Ni and Co varied in intensity under different conditions, pointing to the presence of a third constituent. The pairs 3274·13 ($i=3$) in Ni, and 3274·10 ($i=2$) in Co: 3247·72 ($i=2$) in Ni, and 3247·70 ($1=2$) in Co, correspond with the two strongest lines of Cu, viz. 3274·09 and 3247·68. At the same time contamination by Cu is rendered improbable by the absence of its other lines.

Tellurium. Measurements of 256 lines between $\lambda=4689·0$ and 2142·6 AE. Iron was absent.

Mercury. Measurements of 119 lines between $\lambda=4358·7$ and 2224·9 AE.

Bismuth. 85 lines between $\lambda=4722·8$ and 2187·1 AE.

Antimony. 186 lines between $\lambda=4693·2$ and 2289·1 AE.

Carbon. The difficulty of obtaining the element in an absolutely pure, dense, and conductive form has not been overcome. The materials available were Siberian graphite, gas carbon, crude or compressed, and Moissan's "Carbone sublimé"—all more or less impure. The lines of cyanogen, from the union of the C with the N of the air, also occasionally appear. Measurements of the different spectra are given. S. G. R.

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366. *Telemetrical Focometer.* **W. Stroud.** (Phil. Mag. 45. pp. 91–98, 1898.)—This paper contains a description of an instrument designed to detect whether an object or image is at a distance from it greater or less than a specified range. Two images of the object are obtained, one from each end of the base of the instrument, and are viewed simultaneously in the field of view of the eye-piece. These images are brought into coincidence by shifting the instrument along the optical bank to or from the object. The instrument is used exactly as a short-focus telescope; it is, however, much more accurate than the latter and much more easy to use. AUTHOR.

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367. *Rotatory Power in Liquids, and Temperature.* **P. A. Guye** and **E. Aston.** (Comptes Rendus, 125. pp. 819–821, 1897.)—Generally, the specific rotatory power of a fluid diminishes with rise of temperature, there being no discontinuity in passing from the

liquid state to that of vapour. The rotatory power does not appear to tend towards a limiting value on raising the temperature. There are, however, some exceptions to these laws. For example, the rotatory power of amyl alcohol first falls, and then rises, on raising the temperature. This anomaly may be merely apparent. The vapour of amyl alcohol consists of simple molecules of the formula $C_5H_{12}O$. But in the liquid state, the capillary measurements of Ramsay and Shields show that molecular complexes $(C_5H_{12}O)_n$ exist, the proportion of the latter decreasing with rise of temperature. The phenomenon may therefore be explained by assuming that the simple molecules have a higher rotatory power than the complexes. If that is so, dissociation brought about by means other than heat ought to affect the rotatory power. This is found to be the case. Thus an aqueous solution of the alcohol has a higher rotatory power than a solution in benzene. W. R. C.

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368. *Rotatory Power of Polymers.* **Berthelot.** (Comptes Rendus, 125. p. 822, 1897.)—In support of the assumption put forward in the preceding Abstract, Berthelot observes that the rotatory power of isoterebenthene, $C_{10}H_{16}$, is $-10°\cdot0$, while for metaterebenthene, $C_{20}H_{32}$, it is $-3°\cdot3$. Similarly for styrolene it is $-3°\cdot4$, and for metastyrolene it is $-2°\cdot2$. W. R. C.

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369. *Lambert's Law and Polarisation.* **W. von Uljanin.** (Annal. Phys. Chem. 62. pp. 528–542, 1897.)—This work, which is on lines similar to that of Millican, deals with the theory of the polarisation of light by dull and by polished surfaces. The author shows that all the observed phenomena are explained by the laws of refraction of light which emerges from the body into the air.

E. E. F.

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370. *Mean Horizontal Candle-Power of a Glow-Lamp.* **C. P. Matthews.** (Phys. Rev. 6. pp. 55–57, 1898.)—The author makes a careful comparison of two different methods of determining the mean horizontal candle-power of a glow-lamp.

(1) Finding the mean radius of the candle-power distribution-curve.

(2) Whirling the lamp about a vertical axis of symmetry at such a speed as to eliminate flickering.

He obtains the value 9·655 for (1), and 9·649 for (2). The obvious conclusion is that the two methods lead to the same result when there is no colour-difference. E. C. R.

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371. *Photographic Objectives.* **M. v. Rohr.** (Zeitschr. Instrumentenk. 18. pp. 4–12, 1898.)—The author shows that distortion is not obviated by making the emergent rays parallel to the incident, and therefore it is not obviated by symmetrical lenses. A full historical sketch is given, in which it is shown that English and American opticians were to the fore in the theory of distortion. A. D.

372. *Spectro-Photometer.* **H. Krüss.** (Zeitschr. Instrumentenk. 18. pp. 12–18, 1898.)—A photometer is described, with a Lummer-Brodhun pair of prisms, for comparison both of total light and of each spectrum component. A. D.

373. *Glow-worm Rays.* **H. Muraoka** and **M. Kasuya.** (Annal. Phys. Chem. 64. pp. 186–192, 1898.)—The photographic effect of glow-worm light, apparently exerted through a black-paper covering, is not solely due to the rays shed by the insects, but partly at least to some influence of vapours proceeding from them. Similar photographic effects are caused by moist brown paper, resin, and coffee. Zinc, magnesium, and cadmium exert a similar influence, but mica or glass stops it. An experiment made with cadmium oxide still awaits explanation. A small square was cut out of a sheet of stout cardboard. The square was filled with powdered cadmium oxide. Another piece of cardboard, with a larger square cut out of it, was laid upon the first. A sensitive plate laid on the top was only blackened to the extent of the smaller square, and the blackening could be stopped by the insertion of a piece of copper. E. E. F.

374. *Röntgen Rays and Vegetable Life.* **G. Tolomei.** (Roma, R. Accad. Lincei, Atti 7. 1. pp. 31–39, 1898.)—The result of many varied experiments is that the action of Röntgen rays on vegetable life, in respect particularly of the quantity of gas developed and of the effect upon the growth of bacteria, is the same as that of light, but weaker. A. D.

375. *Kathode Rays in an Alternating Electrostatic Field.* **H. Ebert.** (Berlin. Phys. Gesell. Verh. 17. pp. 2–7, 1898.)—Preliminary discussion of the results of K. E. F. Schmidt as to the deflection of kathode rays by high-frequency alternating electric forces, and as to whether this is due (1) to the magnetic action of displacement currents in the dielectric, (2) to charges on the wall of the tube, or (3) to a special cause of kathode phenomena, the action of an external oscillating field upon the walls of the tube. Of these, (1) and (2) seem to be excluded, while (3) seems to be correct. Experimental details to be published later. A. D.

376. *Kathode Rays and Röntgen Rays.* **A. Battelli.** (Phil. Mag. 45. pp. 163–172, 1898.)—S. P. Thompson thinks there are, within Crookes tubes, a special kind of rays differing both from kathode and from Röntgen rays ('Electrician,' Jan. 8, 1897). From similar data the author and Prof. Garbasso have concluded that the Röntgen and the kathode rays are of an identical character with this difference, that the first only constitute a part of the latter. It cannot be asserted that the kathode rays are reflected as a whole according to the laws of regular reflection. Kathode rays reflected by the reflector of a focus tube can subsequently

undergo a new anomalous reflection similar to the first reflection of the same rays, and may be confidently assumed to possess the same properties as the direct kathode rays. The rays emanating from the posterior part of a very thin sheet, the anterior part of which is struck by the kathode rays, also possess the same properties as these; and the photographic effect of such rays is greater at the back of such a plate, the thinner the plate and the less dense its substance. The photographic action of the surface facing the kathode is the *more feeble* the less the thickness of the sheet. A pencil of kathode rays appears as if made up of various rays of different natures: when they strike on a substance of very small thickness, they seem to possess the power of passing through it, but in the same way as if they passed through a filter which would allow a passage more or less easy to some of them than to others. A. D.

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377. *Discharge of Electrified Bodies by Röntgen Rays.* **C. D. Child.** (Phys. Rev. 5. pp. 193–212 and 285–293, 1897.)—After a *résumé* of articles published on the subject of discharge in gases generally, the author describes his own experiments on the relation between the rate of discharge and the density of the surrounding gas. The curve showing the relation of these is, for 35 volts and above, fairly in accord with Benoist and Hurmuzescu's statement that the rate of discharge is proportional to the square root of the density of the gas. At 6 volts the curve is quite different, and the rate of discharge presents a maximum at a pressure of about 200 mm. Hg. Again, a maximum rate of discharge presented itself, with Röntgen rays, when the pressure was 200 mm., the voltage 8 volts, and the distance between the plate and the surrounding metal 2 cm.; while with ultra-violet light the corresponding data for a maximum rate of discharge are $4\frac{1}{2}$ mm., 100 volts, and 0·8 cm. A thin coating of paraffin on metal seemed to allow a discharge through it, not a mere condenser effect. The experimental results are shown to be in harmony with Thomson and Rutherford's theory (Phil. Mag. 42. p. 392) of the electrolytic conduction of electricity in a gas. The ionisation produced by an interrupted discharge seems to endure for about 0·1 second, and is more rapid when the pressure is low. A. D.

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378. *Secondary Effect of Discharge by Röntgen Rays.* **J. Perrin.** (Comptes Rendus, 126. pp. 243–244, 1898.)—M. Sagnac's secondary rays, much absorbed by the first layers of air they encounter, produce in that air an ionisation analogous to that produced by direct rays. A. D.

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379. *Influence of Röntgen Rays on Electric Spark.* **S. Guggenheimer.** (Comptes Rendus, 126. pp. 416–418, 1898.)—The maximum spark-length was measured between (1) two points, (2) one point and one disc, and (3) two balls when Röntgen rays

were traversing the spark-gap and when not. In every case an augmentation of spark-length was obtained by the use of the rays, the augmentation being greatest with the point and disc when the disc was the positive terminal. If the augmentation was due only to ionisation of the gas, it ought to be greatest when the disc is negative. There must therefore be another influencing factor, possibly the electric density on the negative pole.

Employing the transformed rays produced by passing Röntgen rays through fluorine, the author finds that the effect on the spark-length is increased by the transformation. J. B. H.

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380. *Source of Röntgen Rays.* **J. Trowbridge** and **J. E. Burbank.** (Phil. Mag. 45. pp. 185–191, 1898; and Amer. Journ. Sci. 5. pp. 129–134, 1898.)—Kathode rays and Röntgen rays are given off from every element of a continuous conductor in a Crookes tube at a high vacuum, and this occurs both when the conductor constitutes the kathode and when it forms the anode of an electrical circuit. The so-called Röntgen-ray burn of the skin can be produced by an intense state of electrification. A. D.

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381. *Phosphorescence by Electrification.* **J. Trowbridge** and **J. E. Burbank.** (Amer. Journ. Sci. 5. pp. 55–56, 1898.)—Action of Röntgen rays on fluorite is exactly similar to that of electrification, producing phosphorescence during the dissipation of an electric charge communicated. This phosphorescence is brighter and briefer if the fluorite be heated, the effect being to accelerate the dissipation of the charge. A. D.

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382. *Röntgen Rays and Mineral Phosphorescence.* **J. E. Burbank.** (Amer. Journ. Sci. 5. pp. 53–54, 1898.)—Notes are given as to the phosphorescence of various minerals under Röntgen rays. 12 out of 16 calcium minerals phosphoresced with various colours; felspars are susceptible, and others of the silicates: not metallic ores, as a rule. The effect of heating the crystals is not the same in all cases. A. D.

HEAT.

383. *Isothermal and Adiabatic Transformations of Gases; Determination of "γ."* **A. Leduc.** (Comptes Rendus, 125. pp. 1089–1092, 1897.)—1. *Formulæ relating to Perfect Gases.* The author first states the fundamental relations for perfect gases and then replaces these by others, giving exact results for actual gases. For a perfect gas isothermal transformations are expressed, by definition, by the relation

$$\mathrm{M}pv = \mathrm{RT}, \quad \ldots \ldots \quad (1)$$

in which M represents the molecular mass of the gas, v the volume occupied by unit mass under the pressure p, at the absolute temp. T.

According to the author's experiments relating to molecular volumes, and adopting for the molecular mass of oxygen the number 32,

$$\mathrm{R} = 83{\cdot}075 \times 10^6 \text{ C.G.S.}$$

Adiabatic transformations take place according to the formula

$$pv^\gamma = \text{const.} \quad \ldots \ldots \quad (2)$$

Finally the velocity of sound in such a gas is given by the formula

$$\mathrm{V} = \sqrt{\frac{p\gamma}{\rho}} = \sqrt{\frac{\mathrm{RT}}{\mathrm{M}}\gamma}. \quad \ldots \ldots \quad (3)$$

The application of these formulæ leads to results more or less approximate. The following are the exact formulæ as stated by the author.

2. *Isothermal Transformations.*—Let ϕ be the ratio formerly defined under the name of *molecular volume* (Comptes Rendus, 125. p. 703),

$$\varphi = \frac{1 - y \times 10^{-4}}{1 + (e-1)z \,.\, 10^{-4} + (e-1)^2 u \,.\, 10^{-4}}. \quad \ldots \quad (4)$$

It follows immediately from the definition of ϕ that, for a real gas,

$$\mathrm{M}pv = \mathrm{RT}\phi. \quad \ldots \ldots \quad (5)$$

Hence the coefficient of isothermal elasticity,

$$\mathrm{E}_i = -v\left(\frac{\partial p}{\partial v}\right)_i = \frac{p}{t - \frac{p}{\phi} \cdot \frac{\partial \phi}{\partial p}} = \frac{p}{1 + \frac{p}{\Delta} \cdot \frac{\partial \Delta}{\partial p}},$$

Δ representing the denominator of ϕ.

Frequently $\frac{1}{\Delta} \cdot \frac{\partial \Delta}{\partial p}$ may be replaced by its first term, designated by A. Thus

$$\mathrm{E} = \frac{p}{1 + \mathrm{A}p}. \quad \ldots \ldots \quad (6 \textit{ bis})$$

3. *Adiabatic Transformations.*—Designating by $\left(\frac{\partial p}{\partial v}\right)_a$ the partial derived in the case of an adiabatic transformation, we have

$$\left(\frac{\partial p}{\partial v}\right)_a = \gamma\left(\frac{\partial p}{\partial v}\right)_i. \qquad (7)$$

From this follows immediately the coefficient of adiabatic elasticity,

$$E_a = \frac{\gamma p}{1+\frac{p}{\Delta}\cdot\frac{\partial\Delta}{\partial p}}, \qquad (8)$$

the denominator reducing to $(1+Ap)$.

Equation (7) may be written

$$\frac{1}{\Delta}\cdot\frac{\partial\Delta}{\partial p}dp+\frac{dp}{p}+\gamma\frac{dv}{v}=0. \qquad (9)$$

The relation which for real gases replaces the equation of Laplace is

$$\Delta p v^{\gamma} = \text{const.} \qquad (10)$$

4. *Velocity of Sound.*—It is sufficient, in order to obtain the velocity of sound at T° *under the pressure p* in a gas of molecular mass M, to replace, in the well-known formula, E and ρ by their values given above.

$$V=\sqrt{\frac{RT\phi}{M}\frac{\gamma}{1+\frac{p}{\Delta}\frac{\partial\Delta}{\partial p}}}$$

$$=\sqrt{\frac{RT}{M}\gamma\frac{10^{-4}-y}{10^{-4}+(2e-1)z+(3e-1)(e-1)u}}. \qquad (11)$$

It should be noticed that γ diminishes when the pressure p increases. Also e is proportional to p. It results that, contrary to the received opinion, *the velocity of sound diminishes when the pressure increases.*

5. *Determination of γ.*—According to Laplace the velocity of sound is probably the most precise means of obtaining γ. The author is led to believe, by the consideration of the numbers calculated from his formulæ, that, in fact, the determination of V in a well-dried gas, at a *temperature* accurately known and *uniform*, will lead to exact results.

The following table is given showing the determinations of Wüllner on air and carbonic anhydride at 0° and 100°. The values γ calculated by means of formula (11) and γ_1 calculated by Wüllner are given for comparison. The numbers at 20° are got by interpolation:—

	V (m. per sec.).	γ.	γ_1.
Air at 0°	331·9	1·4066	1·40526
„ 20°....	„	1·406	1·40491
„ 100° ..	387·7	1·4029	1·40289
CO_2 at 0°	259·28	1·3274	1·31131
„ 20°	„	1·320	1·3068
„ 100° ..	300·14	1·2902	1·28212

Application.—These values of γ have been utilised for the calculation of the mechanical equivalent of heat, adopting Regnault's values of C and the data of Joule and Lord Kelvin relative to the internal work. The following are two of the numbers obtained:—

	C.G.S.	Kilogrammetres.
Air at 0°	$4·206 \times 10^7$	428·7
CO_2 at 0°	4·219	430·1

	C.G.S.	Kilogrammetres.
instead of	4·19	427

which appears to result from the best experiments on friction.

The author postpones to a later paper the discussion of the results obtained. J. J. S.

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384. *Molecular Velocity of Liquids.* **G. Guglielmo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 254–261, 1897.)—A theoretical investigation is given of the velocity of the molecules of liquids and its dependence on pressure and temperature, considered under the following heads:—(i) Variations of the molecular velocity as the result of external pressure; (ii) influence of the form of the liquid surface on the vapour-tension; (iii) influence of pressure on the melting-point; (iv) osmosis. For dilute solutions it appears that the theoretical velocity of the molecules of the liquid is approximately equal to the velocity of the molecules of vapour, and for concentrated solutions the expression which agrees best with observation is the following:—

$$v_1^2 = \frac{3}{2}\frac{D_1 - d_1}{D_1 - d_1} h_1 g,$$

where v_1 is the molecular velocity of one of the components of the mixture, D_1 its density when pure, d_1 the weight of it contained in a unit volume of mixture, and h_1 the height of a column of its vapour, such that its tension at the bottom is that of the pure body and its tension at the top is that of the body in the mixture. G. H. Br.

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385. *Steam Calorimeter.* **M. T. Fullan.** (Amer. Electn. 9. pp. 230–231, 1897.)—A description is given of a simple and inexpensive "throttling" calorimeter. The principle of the apparatus is as follows:—Some of the heat contained in high-pressure steam is liberated when the pressure is lowered, and that

heat is utilised in evaporating any water the steam may contain, and in raising the temperature of the steam above that due to its pressure. A throttling calorimeter, however, cannot be used if the steam contains much over 2·5 per cent. of moisture, but it is described as very convenient and accurate within its limits of operation. A curve diagram is given for use with the calorimeter, the vertical divisions representing absolute steam pressures, and the horizontal ones degrees of superheat in the calorimeter. The special usefulness of the apparatus is to detect and measure the amount of wet steam which many boilers produce, particularly when forced or overworked. J. J. S.

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386. *Evaporation from a Circular Basin.* **J. v. Pallich.** (Wien. Akad. Sitzber. 106. pp. 384–410, 1897.)—1. The elliptic curves of equal vapour-tension obtained by Stefan by deductive methods for the space above an evaporating surface are of too small eccentricity to agree with the results of experiment; observation requires this to be about twice as great—in one case the linear (*sic*) eccentricity being 95 mm. instead of 51 mm.

2. The expression

$$v = -\frac{k}{P-p}\frac{dp}{dn},$$

which according to Stefan should give the quantity of vapour diffused in one second across a unit area of section, measured volumetrically, only agrees with experiment if, in calculating the level surfaces, their linear eccentricity is taken nearly double of that obtained by him.

3. The same is the case in calculating the quantity of evaporation V from a circular vessel by the formula

$$V = 4ak \log_e \frac{P-p_0}{P-p_1}.$$

4. The difference between the values obtained from theory and experiment increases as the temperature increases.

5. The equation enunciated by Stefan for calculating the quantity of evaporation from any internal part of an evaporating liquid surface, namely,

$$V_1 = V[1-\sqrt{(1-r^r/a^r)}],$$

gives for the inner portions of the surface too small values, even when the total evaporation from the entire vessel agrees with that found by experiment.

6. If the quantity of evaporation at a point distant r from the centre of the liquid surface be calculated from the formula

$$v_1 = \frac{V}{2\pi a\sqrt{(a^r-r^r)}},$$

the result is too small at points near the centre, and too large at points near the circumference. G. H. Br.

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387. *Thermodynamic Potential.* **A. Ponsot.** (Comptes Rendus, 126. pp. 226–228, 1898.)—The author gives expressions for the thermodynamic potential of a solution in contact with its constituents, and for the condition that water should pass from one solution to another. R. A. L.

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388. *Thermal Conductivity of Ice.* **P. Straneo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 262–269, 1897, and pp. 299–306, 1897.)—1. The coefficient of thermal conductivity of ice is not altogether invariable, but is generally comprised between the limits 0·30 and 0·31, taking as units the centimetre, gramme, minute, and centigrade degree.

2. In ice that is not completely amorphous the conductivity varies slightly in different directions; the following values being obtained in two observations:—

$$k_1 = 0{\cdot}328, \qquad k_2 = 0{\cdot}301,$$

and

$$k_1 = 0{\cdot}325, \qquad k_2 = 0{\cdot}308.$$

The higher values refer to the vertical, the lower to the horizontal directions referred to the position of the ice when frozen.

G. H. Br.

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389. *Constant-Volume Air-Thermometer.* **J. R. Erskine Murray.** (Journ. Phys. Chem. 1. pp. 714–717, 1897.)—An illustrated description of a simple apparatus, easily calibrated, with a movable reservoir of mercury and a graduated air-gauge. Its sensitiveness can be adjusted to the work required. S. G. R.

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390. *Diminution of Clearance in Air-Thermometers.* **G. Guglielmo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 292–299, 1897.)—In open tube-manometers, as well as in air-thermometers, it is desirable that the tube communicating with the gas should be of capillary section; but by reducing its diameter, the error due to capillarity is greatly increased. To avoid this, the branch of the manometer communicating with the gas terminates at its upper end in a cone of semi-vertical angle about 45° with its axis pointing upwards, the mercury being made to reach a fixed point in the cone, and the pressure of the gas being balanced by varying the height of the liquid in the other branch. Two dispositions of apparatus are described, and the second of these serves the additional purpose of a mercurial air-pump, enabling an excellent vacuum to be made, and the exhausted vessel then filled with the gas whose expansion is to be observed. The vacuum is sufficiently perfect for the production of Röntgen rays. G. H. Br.

SOUND.

391. *Combination Tones.* **C. Barus.** (Amer. Journ. Sci. 5. pp. 88–92, 1898.)—The author uses a pipe of constant pitch and a siren of variable pitch. As the siren's pitch increases from zero to the pitch of the organ-pipe, the difference-tones decrease from the latter to zero. Immediately after unison is passed they begin to ascend. The transition is very apparent, even to the untrained ear. The difference-tones and summation-tones of the various orders may be clearly represented by straight lines on a diagram in which ordinates are the pitches of the standard pipes, and abscissæ the uniformly increasing pitches of the siren in terms of time.

E. E. F.

ELECTRICITY.

392. *Magnetic Field due to a Current parallel to an Iron Cylinder.* **G. F. C. Searle.** (Electn. 40. pp. 453–456 & 510–511, 1898.) —When a current flows in a straight wire, in air, parallel to the plane face of an infinite block of iron of constant permeability μ, it is shown that the magnetic force in both air and iron can be derived from a simple system of images. Thus if i be the original current, the magnetic force in the air is the same as that due to the original current i and a current $i(\mu-1)/(\mu+1)$ flowing along its optical image in the face of the iron. The magnetic force in the iron is the same as that which would exist if the iron extended to infinity in *all* directions and the original current were $2i/(\mu+1)$.

It is shown that this magnetic distribution satisfies the conditions of continuity of (1) the normal magnetic induction, (2) the tangential magnetic force, or equivalently the magnetic potential.

By writing $1/\mu$ for μ we have the solution for the case in which the current flows in a wire in a "tunnel" bored in the iron block parallel to its face. Diagrams of the lines of induction, drawn by Maxwell's method, are given for these two cases. The same results are shown to hold for a circuit of *any* form near a plane surface of iron.

When a magnetic force H is applied at right angles to the face of an iron block in the second case, there is a force iH dynes per cm. of the current at right angles to both i and H. This is considered by the aid of the Maxwell stress, and the portions of the force borne by the iron and the wire respectively are calculated.

Finally it is shown that when a current flows in a wire inside or outside a solid circular cylinder, cutting a plane perpendicular to the axis in a point A, there is a simple system of images consisting of currents along the axis and along a line cutting the plane in the point inverse to A with respect to the circular section. The values of these currents do not depend upon the distance of the original current from the axis of the cylinder. AUTHOR.

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393. *Electrostatic Capacity of Two-wire Cable.* **G. W. Patterson.** (Phys. Rev. 5. pp. 309–313.)—If each wire has a radius R, and if the least thickness of the dielectric between the two wires be d, and if the dielectric capacity of the medium surrounding the wire be K ($=1$ for air insulation, about 2 for paraffin, and about 2·25 for rubber), then the capacity in microfarads per centimetre length is

$$(1206\times10^{-10}\text{K})\div\log\left(\frac{\sqrt{4\text{R}d+d^2}+d}{\sqrt{4\text{R}d+d^2}-d}\right).$$

A. D.

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394. *Magnetic Elements on Jan.* 1, 1898. **T. Moureaux.** (Comptes Rendus, 126. pp. 234–236, 1898.)—The following are the magnetic elements for Jan. 1, 1898, at the three French observatories :—

	Parc Saint-Maur.	Perpignan.	Nice.
Declination	14° 56′·0	13° 49′·1	12° 10′·3
Dip	64° 58′·9	60° 3′·1	60° 14′·3
Horizontal force....	0·19660	0·22362	0·22332
Vertical force	0·42125	0·38812	0·39054
Total force	0·46487	0·44793	0·44988

At Parc Saint-Maur the secular variation during 1897 was :—Declination −5′·5, dip −1′·9, horizontal force +0·00034, vertical force +0·00013, total force +0·00027. E. E. F.

395. *Electromotive Force.* **J. Trowbridge.** (Amer. Journ. Sci. 5. pp. 57–58, 1898.)—By means of an improved Planté rheostatic machine, giving up to 1,200,000 volts, the relation of E.M.F. to sparking distance in air was investigated. It was found that at high values the E.M.F. necessary for sparking increased only at the same rate as the sparking distance, which is in direct contrast to the behaviour at low values, and is in agreement with Lord Kelvin's conjecture. F. T. T.

396. *Spark Discharge.* **G. Jaumann.** (Annal. Phys. Chem. 62. pp. 396–406, 1897.)—The author defends his law of discharges from the attacks made by R. Swyngedauw and by Heydweiller. He quotes in particular an experiment made by himself in 1888, which shows the absence of an influence of the form of electrodes on the path chosen by the discharge. E. E. F.

397. *Ultra-Violet Light and Spark Discharge.* **E. Merritt.** (Phys. Rev. 5. pp. 306–309, 1897.)—A lecture experiment is described. In circuit let there be two branches, one containing Geissler tube and spark-gap A, the other containing spark-gap B. Finely adjust B, shortening the gap until the spark runs in B and not in A. Then let ultra-violet light shine on the gap A, and the spark passes through A instead of B, and the Geissler tube shines out. The effect of various screens is also easily shown: quartz and gypsum are fairly transparent; glass is as effective a screen as metal. The effect of illumination seems to be equivalent to shortening the gap by a certain constant amount. A. D.

398. *Potential Gradients in Vacuum Tubes.* **W. P. Graham.** (Annal. Phys. Chem. 64. pp. 49–77, 1898.)—The fall of potential along the path of a vacuum discharge was investigated by means of fixed and movable electrodes. The results obtained by the latter are the more interesting and less liable to objection. Two electrodes were mounted close together on a glass rod entering the vacuum-tube through the Torricellian column. The potential gradient was thus determined all along the path of the discharge. In the stratified positive part, the gradient was steeper in the bright strata than in the dark ones. Maxima and minima are also observed in the dark space, except at higher pressures. Next the electrodes, the gradient has a minimum value. E. E. F.

399. *Canal Rays.* **E. Goldstein.** (Annal. Phys. Chem. 64. pp. 38–48, 1898.)—The canal rays form the yellow layer next the kathode, whose study has been somewhat neglected in favour of the dark space. If the vacuum is divided into two parts by means of a perforated kathode acting as a diaphragm, the canal rays may be obtained free from admixture with blue kathode light. These rays travel in straight lines. From each perforation a feebly divergent bundle of rays emerges, surrounded by a slight mist. As exhaustion is pushed further, the canal rays converge more and more towards the axis of the tube. They form in fact the prolongation of the kathode rays backward, and their direction only depends upon the front surface of the kathode. The canal rays produce no luminescence, and are not deflected by a magnet. E. E. F.

400. *Reflected Kathode Rays.* **Villard.** (Paris Soc. Franç. Phys., Bull. 108. p. 6, 1898.)—In focus tubes, the kathode rays which are not absorbed may be reflected or transmitted, retaining their properties. If there be oscillation set up in the inducing bobbin—which occurs when the tube is hard—the anti-kathode itself becomes a source of kathode rays which tend to obscure the result. A. D.

401. *Coloration by Kathode Rays.* **E. Wiedemann** and **G. C. Schmidt.** (Annal. Phys. Chem. 64. pp. 78-91, 1898.)—The authors support their theory of the coloration of alkaline chlorides by further experiments, undertaken with a view of testing whether such coloration is actually due to the formation of sub-chlorides. The salt was placed in a tube provided with an external kathode, which could be moved along the tube. The salt was exposed to the rays for several days, and shaken up now and then to expose fresh surfaces. On pouring the salt into water containing a little phenol-phthaleïn, a red coloration was obtained. The formation of free chlorine was proved by means of mercury, which formed mercuric chloride. The amount of the salt decomposed is excessively small, but there is no doubt that the coloration is due to a chemical reduction, and not to a physical change. E. E. F.

402. *New Alternate-Current Voltmeter.* **H. Ebert** and **M. W. Hoffmann.** (Zeitschr. Instrumentenk. 18. pp. 1–4, 1898.)—A voltmeter is described, based on the same principle as Bjerknes' plate-electrometer (Wied. Ann. 48. p. 594, 1893). Two figures of the apparatus are given. A. D.

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403. *Application of Vector Algebra to Alternate Currents.* **W. G. Rhodes.** (Elect. Rev. 42. pp. 22–25, 54–56, 90–92, 1898.)—These are three articles on the solution of certain problems in alternating currents by the use of vector algebra. By this method the determination of the equivalent resistances, reactances, and impedances of branched circuits, whether mutual induction is taken into consideration or not, is reduced to the solution of simple equations and the resolution of a resulting vector into two components at right angles. Perhaps the most interesting feature of the method is the ease with which any step in the process may be represented graphically. It is noticeable that there are essential differences between this method and that used by Steinmetz, who treats resistances, reactances, and impedances themselves as vector quantities, whereas in the paper under consideration the only quantities which enter the equations in an explicit manner are electromotive forces and electric currents. The paper is the outcome of an endeavour to treat in a simple manner problems in alternating currents which, while of great importance, are usually considered too difficult to come within the scope of an elementary treatise on the subject. AUTHOR.

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404. *Resistance of Silver Films.* **I. Stone.** (Phys. Rev. 6. pp. 1–16, 1898.)—The paper contains an exhaustive account of some experiments on the resistance of thin films of silver deposited on glass by the "Rochelle Salt Process." The resistance, calculated from the specific resistance of solid silver, is but a small fraction of the resistance of the film. The resistance, however, is not constant, but decreases with time, reaching its lowest value only after an infinite period. When the temperature of the film is kept constant the relation between resistance and time, for a given specimen, can be represented by the equation

$$y = e_1 + c_2 e^{-ktn},$$

where y represents the resistance, and t the time after the production of the film. Heat accelerates the rate of decrease of resistance. It is probable that the age of the solution from which the silver is deposited influences the fall of resistance, the rate being smaller the older the solution. The author concludes that in general "the decrease of resistance with time is caused by a gradual settling down of the silver molecules into a more and more compact mass. Heat accelerates this motion, bringing in a few minutes the film into that condition which time accomplishes only

after months. Preliminary experiments indicate that electric currents and shocks produce a similar effect upon a film as that produced by heat." A. Gs.

405. *Failure of Resistance Coils.* **R. Appleyard.** (Phil. Mag. 45. pp. 157–163, 1898.)—Attention is directed to the serious mechanical weakness of certain alloys, particularly of german-silver and platinoid. Several thousands of specimens, in the form of bobbins of wire, were submitted to India, Brazil, Chile, Peru, Ecuador, Nicaragua, Mexico, and Texas. For comparison and reference others were kept in England. In periods of time varying from a few weeks to three years after this distribution, faulty bobbins were reported from certain localities. It happens that these localities all lie on or near sea-coasts. They are nearly all within the isotherm of high terrestrial mean temperature, 25° C. In all cases of failure, the alloy had become brittle and the wire was broken. Some specimens of wire were rotten from end to end. A short history is given of those that failed. It is shown that failure may occur without electric current, and apart from all ebonite, sulphur, and paraffin-wax. Paraffin-wax is highly absorbent of moisture, and quite useless against climate. The deteriorating effects of heat and moisture are not limited to mixed metals. A large tube made of electrolytic copper, presumably pure, became very seriously "pitted" under the influence of steam. Another tube, of the same electrolytic copper, became similarly "pitted" when used for conveying sea-water. When these were replaced by tubes of ordinary copper, there was no further trouble.

The author suggests that two kinds of brittleness ought to be discriminated—(1) "Primary brittleness," as, for instance, that exhibited by gold when alloyed with lead, with arsenic, or with bismuth. In such cases brittleness is characteristic of the alloy from the moment of solidification. (2) "Secondary brittleness," a subsequent and more gradual phenomenon, as, for instance, that exhibited by certain varieties of german-silver, months or even years after solidification. "Primary brittleness" is an accident of birth; "secondary brittleness" is a disease that develops with age and circumstance. Deteriorated german-silver, or platinoid, when examined under the microscope, is seen to contain crevices and fissures; the section has patches of various colours, corresponding, most probably, to separate masses of "liquated" metal. It is further suggested that by the process of "liquation" homogeneity of structure is lost, consequently the tensile strength of the material varies from point to point of its mass, so also does the electrical conductivity. In passing afterwards through the die of the wire-maker, the weaker constituents give way; thus incipient crevices are formed, and through these capillary channels moisture subsequently intrudes. If such wires are used for electric currents, maximum heating occurs at the weakened sections; this accounts for the failure of german-silver resistance-coils on arc-

light and other circuits. The separate masses of dissimilar metals constitute local circuits of very small resistance, and within these circuits internal currents act destructively upon the alloys.

The secret of permanence in electrical alloys is being studied with a view to commerce by the Reichsanstalt in Germany. British cable-manufacturers are already importing thousands of tons annually of sheathing wires from Germany, and it is to be regretted that, for want of a National laboratory, British instrument-makers will soon be obliged to obtain their resistance-wire from that same source. AUTHOR.

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406. *Gravitational Permeability.* **L. W. Austin** and **Chas. B. Thwing.** (Phys. Rev. 5. pp. 294–300, 1897.)—Experiments are described with a modified Boys' gravitation instrument. With screens of lead, zinc, mercury, water, alcohol, or glycerine occupying one-third of the distance between the attracting masses and the needle, the change produced in the attracting forces is certainly less than 0·2 per cent. of the total attraction. With iron the result is not yet distinct, but any change is certainly less than 1 per cent. A. D.

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407. *Best Resistance for a Sensitive Galvanometer.* **F. A. Laws.** (Phys. Rev. 5. pp. 300–305, 1897.)—If an existing arrangement of apparatus be taken, we can increase its sensitiveness by replacing the galvanometer by a similar instrument wound with wire of a particular size to a resistance equal to *one-half* that of the remainder of the circuit. This best size of wire—taking w as the resistance per unit volume of the wire, C as the diameter of the covered wire, and B that of the bare wire—is that for which $w^{\frac{1}{6}}$. B/C is a maximum. A. D.

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408. *Resistivity of Crystallised Silicium.* **F. Le Roy.** (Comptes Rendus, 126. pp. 244–246, 1898.)—The resistivity varies with the pulverisation, compression, and heating of the material, and is about 1333 times that of electric-lighting carbons; and, like that of carbon, the resistance falls off as the silicium is heated, being about 40 per cent. less at 800° C. A. D.

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409. *Conductivity of Iron Ores.* **A. Abt.** (Annal. Phys. Chem. 62. pp. 474–481, 1897.)—Some of the resistivities obtained are:—

Nickel Ore (Dobsina)......	0·0032
Pyrrhotite	0·0084
Chalcopyrite	1·0176
Magnetite	7 to 4900
Hæmatite	1430
Siderite	7175

E. E. F.

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410. *Electric Curve-Tracer.* **E. B. Rosa.** (Phys. Rev. 6. pp. 17–42, 1898. Also preliminary account, Elect. World, 30. p. 631, 1897, and Electn. 40. p. 26, 1898.)—The author reviews various methods of tracing alternate-current curves, and upholds the step by step method on the ground that this gives the average curve, which is the most generally useful. In the apparatus described a constant potential-difference is maintained between the ends of a wire spirally wound on an ebonite rod, one metre in length, by means of storage-cells; the alternate current to be delineated is passed through a non-inductive resistance, one terminal of which is connected through a dead-beat galvanometer with the middle point of the spiral wire, while the other terminal is joined through a revolving contact-maker to a sliding contact on the spiral. When the sliding contact is so adjusted that the galvanometer deflection is zero, the potential-difference between the terminals of the non-inductive resistance is the same as that between the slider and the fixed contact on the spiral wire, and is proportional to the distance between these points.

The sliding contact is fixed to one end of a pantagraph which carries a marking-point over a recording cylinder; the excursion of the marking-point is proportional to that of the slider, but is reduced in the ratio 8 : 1. By raising a lever, the circuit of an electro-magnet is closed, causing the marking-point to print a dot on the recording cylinder; the downward motion of the same lever actuates a pawl and ratchet gear, which rotates the cylinder one step, and at the same time advances the brush of the contact-maker through a corresponding angle. The lever is operated with one hand, while the slider is adjusted to give zero deflection with the other. Observations may be made very rapidly, as many as 20 points per minute being obtained without difficulty. In an improved form of the apparatus, the recording cylinder and contact-brush are simultaneously set by means of electro-magnets, so that the recording apparatus may be placed at a distance from the contact-maker and alternate-current generator.

A full description of the mechanical details of the curve-tracer is given: and a number of curves obtained under various conditions by means of the apparatus are shown and discussed. Harmonics having frequencies up to 15 times that of the fundamental are reproduced with great fidelity, and the effects of inductance, resistance, and capacity respectively on the wave form are clearly shown. When resistance predominates, the harmonics of the electromotive-force curve reappear in the current-curve unchanged; when the circuit is highly inductive they are damped out, especially those of a high order; and when the capacity is great the harmonics are intensified. The electromotive-force curve is propagated through a series of transformers without any appreciable change.

A. H. A.

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411. *Electric Osmosis.* **F. Braun.** (Annal. Phys. Chem. 63. pp. 324–328, 1898.)—Describes the motions of a membrane

dividing two electrolytes traversed by a current, due to the unequal effect of the salts upon the tension of the membrane. These motions are instantaneous on reversal of the current, and shed some light on certain biological phenomena. E. E. F.

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412. *Thermal Mercury Ammeter.* **C. Camichel.** (Comptes Rendus, 126. pp. 240–242, 1898.)—This is an improvement of the ammeter described last year. It consists of a thread of mercury in a tube which joins two small bulbs containing pure mercury and wire-terminals for insertion in the circuit to be studied. The whole is immersed in the thermometric vessel, and the heat developed in the thread is a measure of the current intensity, the rise of temperature per unit time being proportional to the square of the current. The errors due to cooling and the change of resistivity are rigidly compensated in this instrument. It is particularly suitable for currents between 1 and 2 amperes, and the error is only 0·5 per cent. E. E. F.

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413. *Measurement of Hysteresis Losses.* **G. L. W. Gill.** (Électricien, 15. pp. 40–41, 1898.)—The apparatus used for the above purpose measures the mechanical work performed on a sample of iron, when it is magnetised through complete cycles. The magnetic field is produced by a solenoid wound on a brass tube. This is so arranged as to be capable of sliding vertically up and down, and can be stopped at any position. The sample under observation is placed in a stirrup of small enough dimensions to pass into the solenoid and is suspended from a spiral spring, the point of suspension being above and in the axis of the solenoid. Another spiral spring fixed under the stirrup keeps it in line. The apparatus is so arranged that when the solenoid is in its lowest position, the iron is out of the magnetic field. By raising the solenoid the iron passes through the solenoid and is once more out of the field, when the solenoid has reached its highest position. By this means the iron can be magnetised through complete cycles. The work performed in the up and down strokes can be determined by measuring the attractive force for different positions of the solenoid, and drawing a diagram of forces in function of the positions. The integral of this curve gives the work performed. The forces at different positions can be measured by calibrating the springs which support the stirrup. The author was able by this means to determine the losses by hysteresis in different samples of iron and at different inductions, by observing the elongation of the springs by means of a microscope. In order that this apparatus should be complete, it has been fitted with an integrating apparatus which gives a direct reading of the work performed. The moving parts of the integrator consist of a steel wheel working on a glass disc. The apparatus is calibrated by placing a known weight in the stirrup, and observing the reading on the integrator during a given travel of the solenoid. L. J. S.

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414. *Magnetisation of Clay during Firing.* **G. Folgheraiter.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 368–376, 1897.)—In endeavouring to rediscover the method used in colouring the celebrated black Etruscan pottery, the author notes that all the specimens he examines are markedly and permanently magnetised. Unbaked ferruginous clay, such as is used in the manufacture of common red pottery, is neither magnetic nor susceptible of magnetisation by a powerful field; but at the temperature at which it begins to lose its plasticity and to cease to be disintegrated by water, signs of magnetisation appear, provided the mass is kept in one position in the earth's field during heating; and at a dull red heat, at which temperature the calcium carbonate of the clay is dissociated, the magnetisation is very marked. The Etruscan ware loses the carbon to which its colour is due far below this temperature, and probably consists therefore of red pottery, which after firing is soaked in bituminous liquid and heated to a moderate temperature whilst surrounded with charcoal. J. W.

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415. *Magnetic Detection of Iron.* **W. Duane.** (Annal. Phys. Chem. 62. pp. 543–544, 1897.)—The presence of iron in a body may be demonstrated by the damping undergone by the body when vibrating in a magnetic field. But a more sensitive method consists in suspending the body in a rotating magnetic field. The deflection shown is due to the coercive force, and not to eddy currents, as shown by the fact that it is independent of the angular velocity of the field. The new method is more sensitive than the most delicate chemical reaction for iron. E. E. F.

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416. *New Method of measuring Magnetic Fields.* **E. Bouty.** (Comptes Rendus, 126. pp. 238–240, 1898.)—The method is based upon the mutual induction employed by M. Lippmann in his mercury galvanometer. A conducting liquid, which may be simple tap-water, flows normally to the lines of force of the field to be measured. By means of the capillary electrometer the constant induced E.M.F. between the upper and lower end of the jet is measured. Knowing the amount of flow, the field intensity may be found. The induced E.M.F. is $E = Hvl$, where H is the field, v the velocity of flow, and l the breadth of the jet. The outflow is $D = vel$, where e is the thickness of the jet. This gives for the field

$$H = \frac{Ee}{D}.$$

The velocity may be varied from 0·5 to 17 m. per second, and fields down to 0·5 C.G.S. units may be measured. E. E. F.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

417. *The Hulin Electrolytic Alkali Process.* **J. B. C. Kershaw.** (Electn. 40. pp. 623–625, 1898.)—The author describes the early difficulties met with by Vautin in his attempts to electrolyse fused salt upon a commercial scale with a molten lead kathode. A modification of this original process has been patented by Hulin, who discovered that the difficulties could be overcome by electrolysing a mixture of fused lead and sodium chloride. The lead, electrolytically separated at the kathode, serves to combine with the sodium as it forms, and the molecules of the lead-sodium alloy diffuse into the molten lead without hindrance. This process has been tried upon an industrial scale at the paper-works of MM. Matussière et Forest, Modâne. The crucibles containing the fused mixture of the chlorides were worked in series in sets of four. Each crucible contained a lead and a carbon anode, and 12 % of the current was caused to pass into the electrolyte by the former, in order to maintain the required proportion of lead chloride in the mixture. An E.M.F. of 7 volts per crucible, and a current-density of 700 amperes were used. The author gives tables showing the current and energy efficiencies of the Hulin process, as compared with those of the wet electrolytic alkali processes now at work in this country. A table is also given showing the comparative expenditure upon power by the Hargreaves, Castner-Kellner, and Hulin processes. The higher figure in the case of the latter is expected to be balanced by the economies and gains resulting from the high productive capacity per unit of plant, the high concentration of the alkaline solution produced, and the value of the by-products—spongy lead and lead peroxide. The author states finally that the experimental plant at Modâne is now stopped, and that a Company has been formed, with a capital of £120,000, to carry on the manufacture of alkalies and chlorine products by the Hulin process at Clavaux. A water-power of 5000 H.P. is available at this spot; the works are already more than half completed, and the manufacturing operations are expected to be commenced before the end of the present year.

AUTHOR.

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418. *Electrolytic Separation of Copper from Silver, Mercury, and Arsenic.* **N. Revay.** (Zeitschr. Elektrochem. 4. pp. 313–316, 1898; pp. 329–333, 1898.)—In the first instalment of the paper the separation of silver from copper is dealt with. The difference of potential between these two metals with regard to solutions of their respective salts being about 0·45 volt, there should be no difficulty in separating them by electrolysis, and as a matter of fact, with Classen's apparatus, the kathodal platinum basin being burnished to secure adhesion of the silver, a quantitative deposition of the metal in presence of copper can be effected both in acid and

in cyanide solution. The E.M.F. calculated for the decomposition of silver nitrate is 0·9 volt, whilst 1·34 volt should be required for copper nitrate; and it is found experimentally that a current of 0·2–0·25 ampere at 1·3 volts, over a period of from 5 to 14 hours, completely precipitates the silver from solutions containing from 0·25 to 0·3 gram of silver nitrate and an equal amount of copper sulphate. The adhesion of the deposited silver is facilitated by keeping the electrolyte at about 70°, and excess of acid should be present to prevent the deposition of silver peroxide on the anode. The specimen results quoted are good, the maximum deviation from the mean being 1 in 1000. The addition of excess of potassium cyanide to the electrolyte proves in practice to diminish the reliability of the process; for, although the silver deposit is denser and more coherent, and there is no risk of forming peroxide, the E.M.F. required varies with the concentration of the silver and with the relative amount of copper present. Approximately quantitative precipitation of the silver is obtained only in presence of comparatively small amounts of copper, and if the latter is largely in excess it may happen that it is precipitated first.

In the second instalment of the paper the separation of copper from mercury and arsenic is considered. The potential difference between copper and mercury with regard to corresponding solutions being about 0·4 volt, there should be no difficulty in separating the two metals electrolytically; but in acid solution very unsatisfactory results are obtained, in part owing to the formation of insoluble basic mercurous salts, and in part owing to the precipitation of the mercury in pulverulent form. Sometimes, moreover, owing to the low resistance of the acid solution, the E.M.F., even with a current of 5 amperes, falls below that required for the deposition of mercury. In cyanide solution fairly good results are obtained, provided the relative amount of copper does not exceed about 25 per cent.; the last traces of mercury, however, cannot be precipitated, as when the concentration of the mercury ions falls below 1/384th of the normal, the E.M.F. of decomposition, which is a function of the concentration, becomes greater than that of the potassium cyanide, and hydrogen is liberated at the kathode instead of mercury.

Copper can be separated from arsenic effectively only when the latter is present in pentavalent and negative form, *i. e.* as a salt of arsenic acid, trivalent arsenic being deposited with the copper on the kathode. Good results are obtained with a solution of copper sulphate and potassium arsenate strongly acidified with sulphuric acid, the E.M.F. ranging from 1·6 to 1·8 volts, and the current from 0·01 to 0·04 ampere; the precipitated copper is entirely free from arsenic, except when the E.M.F. exceeds the above limit, in this case the arsenic being reduced. Reduction takes place most readily in hydrochloric-acid solution, and least readily in a sulphuric-acid solution. In ammoniacal solution the results are not quite so good. J. W.

419. *Electrolytic Separation of Copper from Nickel, Iron, and Zinc on a Manufacturing Scale.* **B. Neumann.** (Zeitschr. Elektrochem. 4. pp. 316–322, 333–338, 1898.)—When crude copper is made the anode in an acid bath of copper sulphate, the less positive of the foreign metals present—silver, gold, platinum, bismuth, tin, arsenic, antimony, lead,—pass sooner or later into the anode slime, but the more positive metals—nickel, cobalt, iron, and zinc—remain in solution, and thus gradually reduce the concentration of the copper salt. Moreover, a greater weight of these metals is dissolved than is equivalent to the copper deposited on the kathode, and the electrolyte therefore becomes steadily richer in metal and poorer in acid; iron in particular is dissolved in the ferrous state at low current-densities, but in the ferric state when the density exceeds 0·13 ampere/sq. cm. The question which the author investigates is: Up to what concentration of foreign metals is it profitable to continue the electrolytic deposition of the copper? Alloys of copper and cobalt are only of theoretical interest, on account of the high price of the latter, and those of copper and iron are not worth attention, on account of the sparing intersolubility of the two metals; but the separation of copper from german-silver and scrap-brass, and in particular from the copper-nickel alloy obtained by ordinary metallurgical processes from the Canadian nickel ore, is of technical importance.

Plates of the alloys in question are made the anodes against kathodes of sheet copper in a series of five cells, and the electrolyte, consisting of copper sulphate, strongly acidified with sulphuric acid and warmed to an appropriate temperature, is kept in steady circulation through the series. With copper-nickel anodes (containing 50 °/₀ of each; also 0·63 °/₀ of iron) at 30°, with an E.M.F. of 0·3–0·4 volt per cell, the current-density in the course of 32 hours gradually falls from 0·022 to 0·008 ampere/sq. cm.; the percentage of copper in the electrolyte gradually falls from 0·046 to 0·006 gram per c.c., whilst that of nickel steadily rises from zero to 0·044 gram/c.c.; iron appears in weighable quantity only after the 28th hour. The copper is at first deposited in bright, regular, dense condition, but about the 24th hour it becomes darker in colour, and less regular in surface, and after the 27th hour the deposit is so spongy that it can be rubbed off. At the end of the 32nd hour, the resistance of the cells is so great that it is not worth continuing the experiment. Substitution of pure nickel anodes for those of the alloy at this stage permit of the reduction of the copper concentration to 0·0002 gram per c.c., but the metal is deposited in a still less coherent form, and the amount of nickel dissolved is excessive, for, owing to the sparseness of the copper ions, a large portion of the current is carried by hydrogen ions, and hydrogen is liberated at the kathode. It is thus impracticable on a manufacturing scale to eliminate all the copper from the electrolyte in copper-nickel separation, either with copper-nickel or with pure nickel anodes. The author suggests precipitating this residual copper with sulphuretted hydrogen, obtained practically

free of cost by the action of sulphuric acid on the unroasted copper-nickel sulphide: the resulting solution of copper and nickel sulphates can then be treated electrolytically as above until the copper reaches the limiting concentration. As to the separation of the iron from the nickel sulphate solution, the method of blowing air through the hot solution is useless for manufacturing purposes, as even after 19 hours 25 per cent. of the iron remains in solution.

The results obtained with anodes of brass and copper pyrites are similar, in each case there occurring a point beyond which it is no longer profitable to precipitate the copper electrolytically. In all cases the electrolyte must be fairly rich in copper, and the processes described by various authors, in which the electrolyte consists of sulphuric acid alone, are technically worthless on account of the lack of coherence of the deposit. J. W.

420. *Electrolysis of Platinum Chloride.* **F. Kohlrausch.** (Annal. Phys. Chem. 63. pp. 423–430, 1897.)—Two forms of the chloride were electrolysed, viz., H_2PtCl_6 and $PtCl_4 . 5H_2O$. For the former, the current was kept so feeble that no gas was given off at the kathode. The amount of platinum deposited increased with the current, but not in proportion to it. The valency of the platinum appears to be between 2 and 3, and not 8 as has been supposed. The anode remained unaffected. In the case of $PtCl_4 . 5H_2O$, the extraordinary result was obtained that at low current-densities below 0·02 ampere per $cm.^2$ no platinum at all was deposited. Hydrogen is given off instead, and, at greater current-densities, has the effect of reducing platinum from the chloride. But this is a secondary action. At the anode, oxygen is given off. E. E. F.

421. *Alternate Current Electrolysis.* **R. Malagoli.** (Écl. Électr. 13. pp. 255–260, 1897.)—The author has carried out experiments, chiefly with gaseous products of electrolysis, to determine how far Faraday's laws are modified in the case of alternate currents. The following conclusions are deduced:—(1) For a given electrolyte, even of different strengths, the decomposition is the same for a number of voltameters in series provided the electrode surface is of the same area in each. (2) The amount of decomposition is proportional to the duration of electrolysis. (3) The amount of decomposition is proportional to the number of coulombs that have passed, provided the current-density is constant. (4) The amount of decomposition depends upon the electrochemical equivalents of the ions in question, and upon the difference between the coulombs passing during each half-period and double the quantity of electricity necessary to completely polarise the electrodes. These results are in accordance with the formula

$$d = tne(Q - 2sq_0),$$

in which d is the amount of decomposition, t the duration of electrolysis, n the frequency, e the electrochemical equivalent of the ion under consideration, Q the quantity of electricity flowing

during each half-period, s the surface of each electrode, and q_0 the quantity of electricity necessary to completely polarise unit surface of the electrodes. W. R. C.

422. *Electrolytic Behaviour of Fluorine Compounds.* **A. Miolati** and **U. Alvisi.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 376–381, 1897.)—According to Werner's extension of the stereometric theory of chemical constitution, the valencies of a hexavalent atom proceed from the angles of a regular octahedron, so that it is physically impossible for such an atom to combine with more than six others. The authors show, however, that the diminution of conductivity of an aqueous solution of potassium fluoruranate, $K_3UO_2F_5$, on dilution is consistent only with the assumption that the salt is dissociated into the ions K_3 and UO_2F_5, the latter negative ion thus forming a trivalent complex in which the hexavalent uranium atom is united with seven other atoms. A number of similar salts are examined, but they are all dissociated hydrolytically by water, and thus afford no light upon the question. J. W.

423. *Mass Law.* **B. Kuriloff.** (Zeitschr. Phys. Chem. 24. pp. 697–702, 1897.)—The author gives examples of its relation to β-naphthol and picric acid in benzene solution. The picrate undergoes by rise of temperature an easy dissociation proportional to the amounts of the two substances present; the dissociation being indicated by the change in solubilities of the base and acid. S. G. R.

424. *Chemical and Physical Equilibrium studied by Osmotic Pressure.* **A. Ponsot.** (Comptes Rendus, 126. pp. 335–338, 1898.)—A mixture of substances forming a homogeneous or heterogeneous system in equilibrium being given, the author proposes to find the substances really existing in the mixture, to submit it to variations of temperature, pressure, and composition, and find the relations existing between these variations, and to establish the conditions of equilibrium by means of semi-permeable membranes only permitting the passage of one of the substances. The differential equations connecting reversible pressure, temperature, and concentration changes in the system under these circumstances are briefly deduced from the two laws of thermodynamics; and it is pointed out that these, together with the gas laws and van't Hoff's osmotic pressure laws, give the solution of the problem proposed. No experimental applications are mentioned. T. E.

425. *Composition and Density of Air.* **A. Leduc.** (Comptes Rendus, 126. pp. 413–416, 1898.)—The author compares his results with those of other experimenters, particularly those of Lewy, and discusses the causes of the discrepancies between them. He attributes these to sources of error in the different methods employed. The amount of oxygen present in the air he finds to

vary with the season, the altitude, the proximity of the sea, and also perhaps with the latitude.

In this last connection a comparison of Rayleigh's results with the author's is interesting. The densities of all the gases determined by the two experimenters agree, if the density of oxygen is taken as the standard in each case; but if air be taken as the standard, then all the densities as compared with London air are greater than those compared with Paris air: the inference being that London air is less dense than Paris air—that is, it contains less oxygen. J. B. H.

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426. *Ozone.* **M. Otto.** (Annal. Chim. Phys. 13. pp. 77–144, 1898.)—Otto's researches have already been referred to in Phys. Soc. Abstracts, 1897, Nos. 219, 638, 683. The present paper covers the same ground. It refers to the relation between tension, necessary for producing ozone, and the distance between the glass plates in the arrangements—metal, glass, air, glass, metal; or metal, glass, air, metal, glass: it describes the transformers and ozone-generators: and establishes the law that the yield grows proportionally with the number of periods. With a current at 80 periods and 6500 volts, he obtained 3·718 kg. of ozone in 24 hours, which would correspond to an efficiency of 15 per cent. The air-current through the apparatus should be rapid.

The second, longer part of the paper deals with the action of ozone on methane; on some benzene derivatives with open side-chains, as eugenol, safrol, estragol; monatomic alcohols, glycol and glycerine; phenol, resorcin, hydroquinone, etc.; phenylamine and paratoluidine. The much disputed ozone-determinations are not mentioned on this occasion. H. B.

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427. *The Electric Furnace.* **Gin** and **Leleux.** (Comptes Rendus, 126. pp. 236–238, 1898.)—If the heating of the arc by the current were adiabatic, the temperature would be proportional to the square of the current-density and to the resistivity of the medium, and inversely proportional to its volume specific heat. Adiabatic heating cannot of course be realised, but it can be approximated to by letting the arc play in a medium consisting of the powdered mixture used for the manufacture of calcium carbide. The arc then forms a chamber with a crater at the top, through which the hot gases escape. After cooling, the walls of the cavity are concentrically stratified in successive layers, consisting of shining graphite inside and crystallised calcium carbide outside that, surrounded by the unaltered powder. This shows, in the first place, that the temperature of the arc itself is too high to allow the calcium carbide to remain combined. If calcium carbide is thrown into the crater it is vaporised and dissociated, as shown by the fact that the escaping gas does not form acetylene.

E. E. F.

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428. *Precipitation of Salts.* **A. E. Taylor.** (Journ. Phys. Chem. 1. pp. 718–733, 1897.)—It has been found that in the precipitation of salts from aqueous solutions by alcohol or acetone, the results could be expressed by an equation of the general form

$$(x+\mathrm{A})y = \mathrm{C},$$

where x and y represent respectively the weight of alcohol and of salt in a fixed weight of water. The present paper gives a number of experiments with potassium chlorate and bromide, sodium chloride and nitrate, undertaken with the view of testing the formula.

The conclusion arrived at is that ternary mixtures of this type behave in accordance with the general equations

$$(x+\mathrm{A})y^n = \mathrm{C} \quad \text{and} \quad (x+\mathrm{A})(y+\mathrm{B})^n = \mathrm{C},$$

n being independent of temperature but varying with the precipitant, while A and B vary with temperature and are each characteristic of one of the non-miscible substances, A being a function of y and B of x. S. G. R.

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429. *Transition-Point of a Solid Solution.* **V. Rothmund.** (Zeitschr. Phys. Chem. 24. pp. 705–720, 1897.)—The change in the transition-temperature of a solid substance, capable of existing in two modifications, which is produced by dissolving in it an isomorphous substance so as to form a solid solution, is analogous to the change of freezing-point of a liquid under similar conditions. Assuming that in these solid solutions the relative depression of the vapour-pressure is equal to the molecular concentration of the dissolved substance, so long as this is small, the author obtains the equation

$$t_0 - t_1 = \frac{\mathrm{RT}^2}{\mathrm{Q}}(c_2 - c_1),$$

in which t_0 and t_1 are the transition-temperatures of the pure substance and of the dilute solid solution respectively, Q the heat absorbed by the conversion of the first into the second modification, and c_1 and c_2 the concentrations of the dissolved substance in the two modifications at t_1. According to Nernst's law of partition,

$$\frac{c_1}{c_2{}^n} = k,$$

where k is independent of the concentration and n indicates how many times greater the molecular weight of the dissolved substance is in the second phase than in the first. If $n=1$, we have

$$t_0 - t_1 = (\mathrm{RT}^2/\mathrm{Q})(1-k)c_2\,;$$

that is, the change of transition-temperature is proportional to the

concentration of the dissolved substance when the molecular weight of the latter is the same in both solid solutions.

The author has experimentally investigated solutions of carbon tetrachloride in carbon tetrabromide. The latter forms crystals belonging to the regular system above 46°, which change into monoclinic crystals at lower temperatures. The transition-temperature was determined by the dilatometer and thermometer as 46°·91 for the pure substance; this was depressed by addition of carbon tetrachloride in proportion to the amount added. The depression produced by the addition of one molecule of the chloride to 100 molecules of the bromide varies irregularly from 0°·92 to 1°·16 in different concentrations. T. E.

GENERAL ELECTRICAL ENGINEERING.

430. *The "Allan" Accumulator.* (Elect. Rev. 42. pp. 211–212, 1898.)—In the Allan accumulator, which has been on the market about three years, the paste in both positive and negative elements is supported in a hollow frame having lattices extending from edge to edge on both sides, the paste being forced into perforations in these edges. As the active material is thus in one unbroken mass, and is supported wholly from the outside, the plates are quite free from any tendency to buckle. The rate of discharge for three hours is said to be 1·5 amperes per pound weight of cell, the average energy-capacity at this rate is 9·0 watt-hours per pound, and the total current-capacity 6 ampere-hours per pound. The weight is about 32 pounds per cell, and 40 cells measure outside $35 \times 24 \times 12$ inches high. The accumulator is thus very suitable for traction. J. W.

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431. *Light Accumulator.* **F. Pescetto.** (Ind. Élect. 6. pp. 472–473, 1897.)—The author points out that a high current-density in charging gives rise to evolution of gases, and therefore, in order to render high current-density possible, the gases should have a more easy access to the interior of the active matter or be absorbed by it. Similarly, for high discharge-rate, the acid should have free access. Experiments were carried out with Cruto plates. It was found that by adding to the paste *ulmate d'ulmine* (obtained by suitably treating sugar with sulphuric acid), these objects are to some extent attained. The following results are given, and refer to weight of plate :—

Charge (amperes per kilo).	Discharge (amperes per kilo).	Energy (watt-hours per kilo).
2	4·6	26
2	8·5	24
10	4·6	13
10	8·5	12
20	4·6	7
20	8·5	6·8

W. R. C.

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432. *Ship-wiring.* **E. W. Countiss.** (Amer. Electn. 10. pp. 77–78, 1898.)—The author gives a number of details of American practice in wiring ships for the electric light. The paper is not suitable for abstracting. A. H. A.

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433. *Enclosed Fuse.* **D. J. Cartwright.** (Amer. Electn. 10. pp. 61–62, 1898.) –In this type of fuse the fusible wire is enclosed in a tube of fibre which is tightly closed and provided with slotted lugs at the ends ; these lugs are adapted to be secured to terminals

on the base of the fuse, and are connected to opposite ends of the fuse-wire. Inside the tube, the fuse-wire passes through holes in partitions dividing the internal space into three chambers so as to leave a definite air-space surrounding the wire in the chambers. In this device, when the fuse melts within the central chamber, the heated air and gases formed, in forcing themselves into the outer or end chambers, blow out the arc. A 50-ampere fuse would melt in less than three minutes on a current increase of 25 per cent., and will open a 500-volt circuit of 450-k.w. capacity without noise or flash when short-circuited thereon. A similar fuse has been short-circuited on a 2200-volt alternator within 10 feet of the dynamo without any extra resistance or shunt in the circuit, and opened the circuit without maintaining an arc between the terminals, which were $6\frac{1}{2}$ inches apart. These fuses can be operated in rooms filled with inflammable gas.

C. K. F.

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434. *Electrical Measuring-Instruments.* **H. Armagnat.** (Écl. Électr. 14. pp. 58–66, 1898.)—This paper contains illustrated descriptions of recording electrical measuring-instruments, both for direct and alternating current. The latter portion is devoted to automatic electricity meters—penny-in-the-slot meters,—those described being the Willy and Simpson, the Burchard, the Cousens, and the Dixon automatic meters. W. G. R.

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435. *Phase-splitting Device.* (Elect. Runds. 15. pp. 77–79, 1898.)—**Siemens** and **Halske** have recently patented a method of producing a current from monophase alternating mains which can be made to have any desired phase-relation to the P.D. between the mains. The method consists in connecting across the mains $M_1\, M_2$ (fig. 1) a Wheatstone's bridge network A B C D, the

Fig. 1.

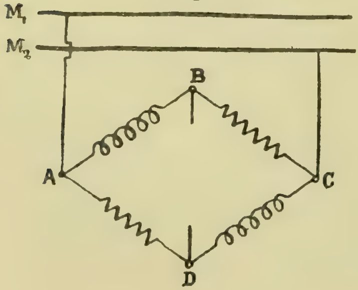
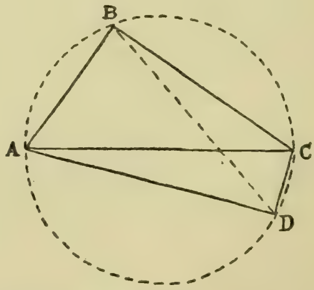


Fig. 2.



required current being tapped off between the points B and D. One pair of opposite arms of the bridge consists of inductance-coils; the other of non-inductive resistances. Fig. 2, which is lettered

so as to correspond with fig. 1, gives the magnitudes and phase-relations of the various P.D.'s in the network (the resistance of the inductance-coils being neglected). It is obvious that by suitably adjusting the values of the resistances and inductances, the line BD (fig. 2) may be made to make any angle with AC. Two examples of the practical application of this method are given. One is in the construction of watt-meters or energy-meters whose moving parts, consisting of a copper cylinder surrounding a laminated iron core, forms the armature of a Ferraris motor, the rotating field being produced by two sets of coils, one of which is placed in the main circuit, while the other is connected across the points B and D (fig. 1) of the Wheatstone's network. If the currents through the two sets of coils be $I_1 \sin pt$ and $I_2 \sin (pt-\alpha)$, then the couple acting on the rotor is proportional to $I_1 I_2 \sin \alpha$. Now if the adjustment be made so that the current in the shunt-coils is exactly 90° in phase behind E, the P.D. of the mains, then it follows that the couple will be proportional to $EI_1 \cos \theta$ (where θ is the angle of lag of the main current behind the P.D.)—*i. e.* to the power. If the couple be balanced by the torsion of a spiral spring, the instrument becomes a watt-meter; but if the copper cylinder is, with suitable damping arrangements, allowed to rotate, we get an integrating watt-meter. The second application of the principle is to the starting of single-phase induction motors. These are provided with a supplementary winding, which at starting is connected between B and D (fig. 1). Experiment shows that an exceptionally powerful starting-torque may be obtained by this method. As soon as the motor gains speed, the supplementary winding is disconnected from the mains. A. H.

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436. *Electrically Lighted Buoy.* (Elect. World, 31. p. 274, 1898.)—A description is given of a buoy invented by **D. M. Fletcher**, which is automatically lighted by wave-power. The buoy consists of a hollow steel shell 6 feet in diameter, which works upon the end of a plunger fixed to the anchorage. The plunger actuates a double-acting pump, which delivers water under pressure to a Pelton wheel coupled to a small dynamo; the latter supplies current to a 50-candle power incandescent lamp in a lantern on the top of the buoy. Means are provided to ensure continuity of lighting. A. H. A.

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437. *Aluminium and Copper.* **A. E. Hunt.** (Elect. Rev. N. Y. 32. p. 118, 1898.)—The writer, who is President of the Pittsburgh Reduction Company, compares the advantages of aluminium with those of copper and brass for electrical conductors. In America copper is about 14 cents a pound, aluminium is 29 cents, giving a cost ratio of 0·48. The density ratio of copper to aluminium is 3·332. Taking the electrical conductivity of copper at 100, aluminium has a conductivity of 63; this refers to the variety specially manufactured for electrical purposes. On this

S 2

basis the sectional area of an aluminium conductor of given resistance and length requires to be about 1·6 times that of an equivalent copper conductor. But since the density ratio is 3·332, the aluminium conductor has a weight only 0·48 that of the copper of same length and resistance. As regards the cost of equivalent conductors, there is consequently little to choose. The writer, so far, only discusses bare wires; he does not consider the additional cost of insulation for the increased section for covered conductors. Tensile strength for a given sectional area is the same both for aluminium and copper; the equivalent electrical conductor of aluminium is thus 1·6 times stronger than copper of equal electrical resistance. It is assumed that for aerial lines the snow-and-ice load is practically independent of the gauge; the advantage here is on the side of copper. As aluminium has less weight and greater strength than the equivalent copper conductor, aerial lines of aluminium can be allowed proportionately longer spans, with a corresponding diminution in the number of poles and insulators.

If aluminium is drawn too severely through the dies, or if it is not well-annealed at the proper intervals in the drawing operations, it is finished much more brittle than is represented by the above figures. Alloying has been adopted with some success as regards increase in tensile strength, but there appears to be a corresponding falling-off in the conductivity. Thus a certain alloy has a tensile strength of 65,000 pounds per sq. inch, with a conductivity of 50 per cent. on Matthiessen's standard. Aluminium is said to resist corrosion much better than does copper. R. A.

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438. *Lightning Protector.* **Siemens & Halske.** (Électricien, 15. pp. 152–153, 1898.)—This guard, made by Siemens and Halske, consists of two pieces of stout copper wire bent in the form of horns and supported on insulators so that they are in the same plane and are near together at the bottom and diverge upwards. One of the horns is connected to the line wire, and the other to earth. When the line is struck by lightning, the arc forms at the bottom and rises, by reason of the heating of the air and the magnetic field produced by the current flowing to earth, until it reaches a definite height, when it breaks automatically. C. K. F.

DYNAMOS, MOTORS, AND TRANSFORMERS.

439. *Walker Alternator.* (Elect. Engin. 21. pp. 83–84, 1898.) —An illustrated description is given of the new type of inductor alternator built by the Walker Company, U.S.A. The revolving inductor has, besides the usual exciting coil, a coil which is supplied by the rectified current from a portion of the armature circuit, the alternator being thereby compounded for incandescent lighting. A. H.

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440. *Testing Dynamos.* (Amer. Electn. 10. pp. 80–81, 1898.) —Two methods are described, specially applicable to small machines whose friction losses would be less than those in any of the usual extraneous testing devices.

(1) With small machines up to $\frac{1}{2}$ H.P., mount the armature between lathe-centres, so that it can be driven as a generator; counterbalance the field-magnets, so that they will remain in any position relatively to the armature, taking care that any metal attached for this purpose does not affect the magnetic circuit: bolt to the magnets a lever-arm, carrying a pointer moving over a scale against the pull of a spring-balance, and damped by a water dash-pot. Adjust the tension on the spring-balance till the pointer is at zero when the armature is (1) at rest, (2) revolving so as to generate full load. Then, if L is the length of the lever-arm in feet [and P is the difference in the readings of the balance when the armature is stationary and when] revolving at N revs. per min., the work put in is 2πLN[P] [by an obvious slip the author forgets to bring any 'P' into his results], while the output can be deduced from the volts and amperes generated.

(2) A calorimetric method: the dynamo is placed inside a felt-covered box through which air is pumped, the quantity being measured by an anemometer and the temperature noted at inlet and outlet. Knowing the specific heat of air, the losses in the dynamo can at once be obtained in thermal units, which, when divided by the constant, are converted into H.P. The method is inaccurate and very troublesome. E. H. C.-H.

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441. *Four-pole Dynamo.* (Elect. Rev. N. Y. 32. p. 47, 1898.) —The General Electric Co. describe a new line of four-pole dynamos. The frame is of cast iron, with soft steel pole-pieces, which are detachable, so that the field-coils can be removed without disturbing the armature. The armature is built up of japanned sheet-iron laminations, mounted on a cast-iron spider. The windings are copper coils formed and insulated before assembling on the core. The temperature rise, after a full-load run of 10 hours, will not exceed 55° C. for the commutator, or 45° C. for any other part of the machine. R. B. R.

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442. *Armature Connection.* **A. L. Rice.** (Amer. Electn. 10. pp. 56–58, 1898.)—The author describes, with diagrams, a two-pole gramme winding and two varieties of two-pole drum winding, lap winding, and wave winding. Taking in each case a drum armature with 24 bars, numbered consecutively, in lap winding the connections are 1 to 12 at back, 12 to 3 at front, 3 to 14 back, etc., giving a back pitch of 11 and a front pitch of 9; in wave winding the connections are 1, 12, 23, 10, 21, etc., giving a front and back pitch of 11. The paper is illustrated by clear diagrams.
R. B. R.

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443. *Rushmore Multi-voltage System.* (Elect. Rev. N. Y. 32. pp. 76–77, 1898.)—S. W. Rushmore found that, by properly distributing the current in the armature and controlling the excitation of the different poles, an ordinary multipolar generator can be made to deliver its output at as many different and independently variable voltages as there are pairs of field-poles, so that each pair of poles constitute, as it were, a separate generator with the voltage from each pair of brushes independently variable from zero to a maximum without the least mutual interference. This being the case, one pair of brushes may lead to a lighting circuit and another pair to a motor circuit without the lights being in the least affected by the stopping or starting of the motors, and the speeds of the motors may be varied at pleasure by simply varying the electromotive force supplied to them by the dynamo.

In connection with accumulators, the machine may run in parallel with the cells at full load, and at light load one or more pairs of brushes may carry the load, while the other pair is connected to the battery, and the voltage is raised to any amount for charging.
W. G. R.

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444. *Single-Phase Motors.* **A. C. Eborall.** (Elect. Rev. 42. pp. 31-32, 67--68, 136–137, 172–173, 276–277, & 355-366, 1898.)—These papers are notes upon single-phase alternating current-motors. Single-phase motors are grouped under three broad divisions:—

I. Constant magnetic field-motors;
II. Alternating magnetic field-motors; and
III. Induction motors.

Under Class I. come synchronous motors, which, as is well known, require to be run up to synchronous speed by some external means before being switched on to the alternating mains. Attempts have been made to make synchronous motors self-starting by laminating the fields and by passing the supply-current both through them and the armature at starting, thus causing the motor to run up to speed as an ordinary series or shunt-wound motor. Synchronism having been attained, the line-current would be switched on the armature and the fields excited by a direct current. On account of the difference, often wide, between the self-inductions of the field and armature windings, the starting torque is but small.

At starting this motor belongs to Class II., of which but little is said, since a really good alternating magnetic field motor has not yet been produced. They all possess the disadvantages of having (1) low efficiency, chiefly due to the hysteresis and eddy-current losses; (2) large "no-load" current and low power factor; (3) heavy sparking, especially at starting and overloads; and (4) low weight efficiency.

In considering induction motors the author goes into details of the construction of the stator and rotor as well as into general theoretical considerations. The essential points in the design of induction motors are as follows:—

Firstly, both stator and rotor should be quite smooth all round, large polar projections on either being avoided.

Secondly, the air-gap must be only just large enough to permit the rotor to run freely with danger of touching the stator. As the no-load current and power-factor at all loads depend mainly on the size of the air-gap, it is clear that it must be as small as possible; also the larger the air-gap the greater will be the leakage.

Thirdly, the rotor currents must be confined to proper paths, so as to keep the heating losses as low as possible and to make the torque for a given current as high as possible.

Lastly, the arrangement of the stator winding and iron parts must be such that the leakage field is a minimum, otherwise there may be eddy currents in the motor-frame, and even in the stator-conductors themselves, causing loss of energy.

The information contained in these articles relating to the construction of motors is valuable, but the theoretical portions are sometimes rather vague. One of the disadvantages of the squirrel-cage rotor for motors is, the author states, that the motor is liable to burn out. This may be said to be a disadvantage of any motor, either of the direct or alternating current types. One thing is certain, and that is the induction motor with short-circuited rotor bars will stand a greater overload than any other type of motor without undue heating.

The following table shows the efficiencies and power-factors of single-phase motors made by Brown, Boveri & Co.

Horse-power.	Approximate weight (in pounds).	Full-load efficiency (per cent.).	Apparent Watts per H.P.
0·1	40	50	2260
0·3	60	60	1750
1·0	140	65	1570
2·0	240	70	1420
3·5	400	73	1330
6·0	620	76	1240
9	1000	80	1150
13	1400	84	1080
20	1700	88	1020
35	3100	90	1000
45	4000	90	1000
65	5200	90	1000
90	6800	91	990

[*To be continued.*] W. G. R

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

445. *Electrical Distribution on the Oxford System.* **J. H. McLean.** (Lightning, 13. pp. 75–77, 1898.)—The author discusses the special advantages of the Oxford system, and gives a brief account of some improvements in the method of working.

A. H. A.

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446. *Line-effects in Alternate-Current Transmission.* **H. E. Raymond.** (Amer. Electn. 9. pp. 219–220, 1897.)—This article deals with some of the so-called line "effects," and the author is of opinion that in designing and laying out the line for an alternating-current transmission, all calculations must be based on the individual requirements of the case. The troubles are usually due to the prevalence of induction, electrostatic, and capacity stresses, these effects increasing greatly with its length. In the author's experience the most serious and troublesome effects have been those due to electrical resonance. It has been found that for every line there is a certain natural period of wave oscillation, just as there is in a bridge or floor, and if this electrical oscillation is such that the machine frequency will coincide with it, the resultant vibration may raise the actual voltage to a great extent. An instance is mentioned of a 3-phase line $4\frac{1}{2}$ miles long, operating normally at between 2500 and 3000 volts, having voltages of from 3500 to 3700 volts developed in it due to resonance effects. One trouble due to this rise in voltage is that the normal spark-gaps of the lightning arresters have to be increased, and the risks on the plant due to a lightning discharge are consequently increased.

The author is of accord with Dr. Louis Bell that insulation on the wires themselves for an overhead line is practically useless. The only real use of overhead-line-wire insulation is in the protection of the line from falling branches and trees. It would probably be cheaper to make a considerable detour than to try to insulate the wires, so as to render them safe against short circuits and earths.

A few notes are given with regard to the dead-ending of wires on poles, and a sketch is given of a convenient and effective method of carrying this out. Regarding the advisability of having more than one line wire it is difficult to judge. If the continuous operation of the system was of great importance, and if the cost of a shut-down were great, while the power transmitted was considerable, it appears that two lines would be advisable if the country and climatic conditions were unfavourable. If the cost of the extra line would not be justified by saving the expense of an occasional shut-down, it seems advisable to so arrange the line that all

the wires in service could be on one side of the arm and at such a distance from the pole that a man could with some safety work on the otherside. L. J. S.

447. *Electricity in Paper Making.* **C. F. Scott.** (Elect. World, 31. p. 274, 1898.)—The Cumberland Mills, near Portland, Me., U.S.A., are worked by power electrically transmitted from a waterfall 4 miles distant. Two 300 H.P. 2-phase generators, coupled to 48-inch Victor vertical turbines, supply current at 1100 volts to four transformers ; these raise the pressure to 8000 volts for transmission on the 3-phase system to the mill, where the pressure is reduced by transformers to 400 volts for supplying 2-phase induction motors. Seven motors are in use for driving machinery etc., two of these being coupled to direct-current generators for electrolytic work. 250 H.P. is also transmitted by direct current at 500 volts from a waterfall 1 mile distant. The motors are subject to severe conditions, such as exposure to chlorine gas, dampness, and sudden stoppages, but they give no trouble. The efficiency of the plant is found to be about 76 per cent., from the B.H.P. of the turbines to that of the motors, and a marked saving is effected in comparison with steam power. A. H. A.

448. *Electric Transmission for Paper-making.* **L. Bell.** (Elect. World, 31. pp. 269–270, 1898.)—The author considers the chief use of electricity in paper-making to lie in the transmission of power from waterfalls, and states that with coal at $3·00 per ton it is more economical to transmit 500 H.P. or more by electricity from a distance of 15 miles than to use steam power. Electrical transmission is not only cheap, but also reliable ; and the difficulty formerly experienced in automatically controlling the speed of turbines is now overcome. Assuming, for example, that a mill requires 1000 H.P. continuously, and that sufficient water-power is available 10 miles away, the author gives the following approximate estimate of capital cost :—

Three 500 kw. polyphase generators, wound for 6000 volts, erected complete	$30,000
Line for 10 per cent. drop, complete	20,000
Step-down transformers for 1000 H.P.	5,000 to 6,000
Motors for 1000 H.P.	15,000 to 20,000
Total cost of electrical equipment, including station, say	80,000
Cost of water-privilege and hydraulic equipment, say	80,000
Total investment for 1000 H.P. day and night	$160,000

The running expenses are estimated as follows :—

Interest at 6 %, depreciation at 4 %, insurance and taxes at 2 %	$21,600
Labour	6,500
Stores etc.	5,000
Total annual cost of 1000 H.P. day and night	$33,100
Cost per horse-power year	$33·10

Using steam-plant of first-class quality, with coal at $3 per ton, the cost per horse-power year would be $50 ; the saving therefore amounts to at least $15,000 per year.

Electrical heating of the drying rolls etc. is impracticable, on account of the great expenditure of energy involved ; the author suggests the use of producer-gas for this purpose. A. H. A.

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449. *Power Transmission in Montana, U.S.A.* (Amer. Electn. 10. pp. 51–55, 1898.)—An illustrated description of the plant to be used for transmitting about 4000 H.P. from a generating station on Big Hole River to the city of Butte, Mont., a distance of 20·6 miles. Four 66 in. double turbines, each developing 1200 H.P. at an effective head of 60 feet and a speed of 180 revs. per min., furnished with Lombard water-wheel governors, are to drive four 3-phase generators of 1000 H.P. each, delivering current at 800 volts to 12 step-up transformers (air-blast type) of 250 kilowatts each, the power being transmitted at 15,000 volts. The line consists of six No. 1 B. & S. gauge conductors, forming two three-wire circuits, and carried by porcelain insulators of the double-shed type supported on 10 ft. 6 in. cross-arms fixed to poles of Oregon fir. The poles are spaced 105 ft. apart. A cross-arm above the conductors carries three glass insulators, on which is strung a triple barbed-wire lightning-protector, glass being used for supporting the (earthed) barbed wires, in order to prevent friction and consequent breaking. The periodicity is 60. A. H.

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450. *Accumulator Installation at Fribourg.* **R. B. Ritter.** (Électricien, 15. pp. 129–135, 1898.)—The electrical generating plant of the State of Fribourg, which has replaced the original teledynamic installation, is driven by water-power obtained from the River Sarine, and supplies electrical energy on the three-wire direct-current system to the town of Fribourg, distant about 1500 m. Two turbines are used, driving four Thury dynamos with a total capacity of 500 kw. ; there are two distribution networks, one for motor supply at 700 volts across the outers, and one for lighting at 300 volts across the outers. In order to cope with an increase in the demand, two batteries of accumulators have been installed in the cellars of the Town Hall, where also the feeders and mains terminate. The cells are of the Theryc-Oblasser type, each plate being enclosed in a sheath of perforated celluloid,

which supports the active material in place. There are 83 elements in each battery, having a capacity of 2600 ampere-hours at a discharge rate of 130 amps., or 1400 amp.-hrs. at 400 amps., with a fall of pressure of 10 per cent. Each element consists of 50 plates. 250 mm. × 200 mm., contained in two glass cells, and weighing 138 kg. in all. As the maximum pressure obtainable from the lighting generators is 175 volts, a number of the cells are cut out of circuit when the main batteries are charged; these cells are separately charged by means of a 50 H.P. Lundell motor run off the 300-volt circuit, which drives two charging dynamos. The latter are protected against reverse currents by Alioth automatic switches, of which a description is given.

The discharge is regulated by the Trumpy system of automatic gear; relays connected by pilot-wires with the distributing network actuate regulating switches, which cut out or add cells as required to keep the pressure constant. Diagrams of connections are given, with a description of the apparatus. A. H. A.

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451. *Worm-Gearing for Traction Motors.* (Amer. Electn. 10. pp. 81–82, 1898.)—The advantages claimed for worm-gearing, as opposed to spur-gearing, are:—(1) That the former allows the use of high-speed, and therefore lighter and cheaper, motors; (2) the motor can be at a distance from its driven axle, on which only the weight of the worm and gear need bear directly; in the case of a double truck, the motor driving one axle can be supported on springs over the other axle; (3) the saving in cost on the smaller motor would allow of wrought-iron magnets and laminated pole-pieces, thus increasing the torque; (4) greater clearance can be obtained between the motor and the road-bed; (5) since worm-gearing is not a reversible combination, it forms an efficient brake when current is cut off; (6) repairs to small motors are easier and cheaper. The one disadvantage noticed is that a disabled car can not be towed without detaching the worm-gear.

The author suggests rolling friction as a possible improvement in worm-gearing, and predicts that double-reduction gearing, which superseded the more efficient single-reduction gearing, will in turn give place to worm-gearing, the loss in efficiency being outweighed in both cases by advantages gained in other respects.

E. H. C.-H.

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452. *Motor Cars on Railways.* **B. Tromieu.** (Écl. Électr. 13. pp. 260–264, 1897.)—The author gives some account of the motor cars employed by the Compagnie du Nord on their railway for postal purposes or when the traffic is very light. The cars are either steam or electric. A steam car has been in use for some time; it is fitted up according to the Serpollet system, and requires practically no attention, so that a single driver is all that is required. Twelve seats are provided for passengers. The weight is nearly 15 tons. This car is used for the postal service between Beauvais and Creil. In running from Paris to Beauvais with two

trailers, the total weight of train being about 36 tons, the consumption per kilometre amounted to $2\frac{1}{2}$ kilogrammes of brickets and $9\frac{1}{2}$ litres of water: the mean speed, excluding the one stop which was made, was 46·2 kilometres per hour.

The electric car is $14\frac{1}{2}$ tons in weight complete. It carries a single direct-driving motor of about 20 H.P., and a battery of accumulators 3·8 tons in weight. The battery, which consists of forty cells made by the Société pour le Travail Électrique des Métaux, is carried beneath the truck and can be easily removed. A car capable of carrying fifty persons is also contemplated: in this case the total weight will be 24 tons, the battery amounting to $5\frac{1}{2}$ tons. W. R.C.

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453. *Accumulator Tramway Traction at Ostend.* **E. Piérard.** (Électricien, 15. pp. 135–136, 1898.)—Experiments are being made at Ostend on the propulsion of tramcars by means of accumulators of the Marschner type; these are made with a special paste, which gives the plates the necessary porosity together with great solidity. The battery consists of 96 cells in 12 sets, weighing in all 2600 kg.; each cell weighs 27 kg., and has a capacity of 400 ampere-hours, or 14·8 amp. hrs. per kg.

A car fitted with this battery has made several journeys, including one from Ostend to Ypres and back (147 km.), at a mean speed of 26 km. per hour; the current varied between 40 and 60 amperes, or 1·4 and 2·2 amps. per kg. The car has also travelled from Ostend to Blankenberghe and back (42 km.), towing loaded trucks. On account of the large capacity of the battery, a single charge would suffice to propel a tramcar for a daily run of 150 km. So far the battery shows no signs of wear and tear; but it remains to repeat the experiments under the ordinary conditions of tramway working, in order to ascertain whether the results given above can be maintained in practice. A. H. A.

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454. *Contact Plough for Conduit Lines.* (Elect. Engin. 21. p. 20, 1898.)—A new plough is described which is lifted out of the slot in case of obstruction in the latter. The plough is suspended from levers pivoted on the frame of the car, in such a way that it is held in a vertical position. One of these levers is connected with a bar for raising the plough by hand; the second lever is connected with a spring by a link, which engages with a stop when the plough is down. Two trip-levers are provided, either of which, on meeting with an obstacle, releases the catch, and allows the spring to raise the plough clear of the slot; these levers also protect the plough from injury. A. H. A.

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455. *Three-Phase Traction at Neuchâtel.* **R. B. Ritter.** (Ind. Élect. 6. pp. 470–472, 496–500, and 520–523, 1897.)—An account is given of the transformation of the horse-tramway (originally worked by gas) from Neuchâtel to Saint Blaise into a trolley line. The distance is 5 kilometres (3·1 miles). Various systems were

considered before coming to a decision. Three-phase current was available from the mains of Neuchâtel at a price of 195 francs (£7 16*s.*) per H.P.-year, and at a pressure of 4000 volts. The firm of Alioth recommended the use of rotary transformers giving a continuous current at 550 volts, to be worked in conjunction with a storage battery. The estimated difference in cost by the use of a battery is given below:—

	Half-hourly service.		Twenty-minute service.	
	Without accumulators.	With accumulators.	Without accumulators.	With accumulators.
H.P. required	50	20	60	30
H.P. taken up by battery	......	30	......	30
Total	50	50	60	60
Capital outlay in Station, in francs	19,100	31,100	20,000	35,900
Cost of working, in francs	11,160	9,600	13,100	11,300

Two other systems were considered, viz., a steam-plant, including two 60 H.P. engines and dynamos; and a Dowson gas-plant, including two 35-H.P. gas-engines and dynamos, together with a battery of 60 ampere-hours capacity. The estimated outlay and working expenses of the three systems are as follows:—

	Capital outlay on Station, in francs.	Annual working expenses, in francs.
1. Three-phase plant	35,900+14,000 (building)	14,590
2. Steam plant	63,500+20,000 ,,	24,960
3. Dowson gas-plant	69,300+20,000 ,,	23,866

The three-phase system thus appearing to be the most economical, it was adopted, and plant was erected sufficient to allow a regular service every half hour by running a car and a trailer from each end of the line, and also an intermediate car upon part of the line. On holidays a twenty-minute service is required.

The three-phase current at 4000 volts is first transformed down to 337 volts, and then, by means of the rotary transformers (two in number), into continuous current at 550 volts. The latter are 40 kilowatt machines. Economy in starting them up is effected by the use of subdivided three-phase transformers for that purpose. By this means a low pressure is at first applied and gradually increased as the machine gets up speed. The battery consists of 300 Tudor cells, and is fitted with an automatic regulator. In order to obtain the pressure necessary for charging the whole

battery, a third small rotary transformer is used, the E.M.F. of which is readily adjusted so as to complete the charge of cells which have to be cut out of circuit during the times of charging by the other machines. The rails are bonded, and a bare 7 mm. wire is also placed in the ground and attached to the rails every 50 metres. The cars, constructed by the Société Industrielle Suisse of Neuhausen, are each provided with two Oerlikon motors of 12 H.P. (85 % efficiency). W. R. C.

456. *Street Sprinkler for Electric Tramways.* (Elect. Rev. N. Y. 32. p. 115, 1898.)—A new type of sprinkler by the Miller-Kniblock Co. is described. Two electrically-driven pumps at either end of the car force the water through four sprinklers at the corners. A lever at each end regulates the force of the spray, which can thoroughly cover a street 100 feet wide. The capacity of the sprinkler is 2500 gallons of water, all of which can be thrown to the full distance. E. H. C.-H.

457. *Rail Driller.* (Lightning, 13. p. 88, 1898.)—A description and illustrations are given of the 'Paulus' and 'Buda' drills introduced by Messrs. Laing, Wharton & Down, Ltd., for drilling rails *in situ*, by which it is claimed that a $\frac{7}{8}$ in. hole in a 90 lb. rail can easily be drilled in two minutes. The machines are of the 'monkey' type, power being applied to handles by two operators standing, and transmitted to the ratchet-fed drill by two sets of bevel gear. The upright which carries the driving shaft is supported from a sole-plate by rule-jointed stays. In the tramway pattern, the drill is held up to its work by two hooks over the head of the rail, and to allow trams to pass over, the upright is folded back, thereby slackening the hooks which are then swung off the rail. For main line express traffic a special type is made with hooks to pass beneath the rails. E. H. C.-H.

458. *Electric Lighting for Profit.* **A. Dow.** (Elect. Rev. N. Y. 32. pp. 94–95, 108, and 124, 1898.)—This is a paper on the commercial aspect of electric lighting stations. It is summarised as follows:—(1) The electric lighting business should pay, as a reasonable profit, approximately the same rate as any manufacturing business which has similar risks. This profit should be paid after the expenses of operation, maintenance, and depreciation, shown by annual inventory, have been provided for. (2) Rates for electric supply should be so adjusted that each unit sold will pay its share of operating and standing charges, and in addition a uniform proportion towards profit. No business should be done at a loss, and no business should pay more towards profit than its proper share. (3) Every class of business that can be profitably done should be obtained. Business that improves the load factor should be taken if it can be obtained at any price greater than its share of operating and standing charges, because the improvement of the load factor reduces the amount of standing charges to be borne by the existing load. (4) Business once obtained

should be kept by careful study of and prompt attention to the requirements of each customer. It is not possible in the present stage of electric development for an electric supply company to limit its interest in the supply to its delivery on the customers' premises. It must do much work in order to secure that the customer uses the supply to the best advantage. It is not sufficient that a customer should be well served; he must also be well pleased. (5) There is need of educational work to be done among electric light men, among municipal authorities, municipal theorists, and among customers. W. G. R.

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459. *Gas-driven Lighting Plant.* (Elect. Engin. 21. pp. 6–10, 1898.)—In this article a description of the electric lighting plant of the Midland Railway Company at Leicester, and a statement of the results obtained, are given. The installation includes 113 10-ampere arc lamps in 7 series circuits, 28 arc lamps run 2 in series on the low-tension circuits, and 320 incandescent lamps ranging from 8 c.p. to 32 c.p. at 110 volts.

Three 50-light Brush arc-lighting dynamos and three low-tension dynamos are installed, the total capacity being about 137 kilowatts; a Sayers compensator, consisting of a series-wound generator driven by a shunt-wound motor, is used to compensate for the loss in the low-tension feeders. The arc circuit switch-board is specially designed to dispense with the use of flexible cords and plugs, by means of a system of panels with dynamo and lamp circuit contacts on each, and movable switch bars to make the connections.

The dynamos are driven by gas-engines using Dowson gas, and provided with special lubricating devices for continuous running; gas can also be obtained in case of need from the town mains.

There are two complete sets of Dowson generators, in which anthracite coal is used. Formerly the consumption of coal amounted to 4·6 lbs. per Board of Trade unit, but by using small coal (which is also cheaper) and a shallow fire, the quality of the gas has been greatly improved, and the consumption of coal reduced to 3·03 lbs. per unit.

The detailed costs of working for the half years ending June 30th, 1896 and 1897, are given below. These figures include the cost of town gas; it is stated that if none of the latter were used the cost per unit would be reduced to 2·67*d.*

	1896.	1897.
Arc lamps in use	137	141
Incandescents	288	320
Total units	126,514	137,070
Total cost	£1,631 9*s.* 1*d.*	£1,604 15*s.* 9*d.*
Total cost per unit	3·09*d.*	2·8*d.*
Labour per unit	1·42*d.*	1·49*d.*
Stores and carbons	1·19*d.*	·86*d.*
Repairs	·13*d.*	·16*d.*
Coal	·32*d.*	·18*d.*

A. H. A.

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460. *Charging for Electrical Energy.* **G. Claude.** (Ind. Élect. 6. pp. 465–470, 1897.)—The author at first deals generally with the encouragement of the use of current for other purposes than lighting so as to improve the load curve; and then passes on to the question of tariff. The Wright system fails in the case of consumers who use their light for only a short part of the year. These, owing to the small number of units which they consume, do not pay a sufficient sum to compensate for the fixed charges incurred in meeting their demand. This defect would be overcome if the Wright indicator showed the amount due for fixed charges, instead of the maximum demand. Some customers would, however, object to the payment of a lump sum. The Wright system also fails in that it makes no distinction between two consumers having the same maximum demand but who differ widely in the number of units consumed. It would be preferable to have a discount system to come into force after a customer has consumed the requisite number of units at the full price. The author proposes in the first place to charge a certain sum depending on the maximum demand; this charge, however, being lower in proportion as the demand is greater, otherwise large consumers would be discouraged. Thus the charge per kilowatt demanded might be expressed by the following formula

$$p=\frac{a}{x+b},$$

and the total charge on this account would be $\frac{ax}{x+b}$, in which a and b are constants, and x the maximum demand. In the second place, the price per unit should grow less as the consumer increases his consumption or load factor, apart from the question of maximum demand. Hence the price per unit should be of the form :—

$$p=\frac{a_1}{f+b_1},$$

in which a_1 and b_1 are constants, and f is the mean load factor of the consumer. The number of units consumed in time t is tfx, and thus the amount due on that account is $\frac{tfx}{f+b_1}$. The total price per unit is, of course, the sum of the two charges. Such a method of charging would lead to an increased use of current in hours of daylight and thus a larger load factor for the supply station.

W. R. C.

TELEGRAPHY AND TELEPHONY.

461. *Cable from Fire-Island to Conklin's Point.* (Elect. Rev. N. Y. 32. pp. 102–103, 1898.)—Sighting towers have recently been established outside New York, by the American Postal Telegraph-Cable Co., for the purpose of reporting shipping. The terminal tower on Fire Island now communicates by land lines, and a cable in Great South Bay, with Brooklyn, New York, and intermediate stations. The cable contains six cores, in three pairs, insulated with okonite ; it is sheathed with galvanised iron wire. Its total length is six statute miles, diameter 1·75 inches, total weight 65 tons. Owing to the shallowness of the water, the shifting shoals, and the sand-bars in the Bay, some care was necessary in laying the cable. The method was to coil it on the flat bottom of a barge, and then to pay-out under a sheave astern, piloted by a small-draught tug. R. A.

462. *Switchboards for Private Telephones.* **Mandroux.** (Électricien, 15. pp. 97–101, 1898.)—The author classifies the systems into those using (*a*) two cords and (*b*) one cord ; the former group is described under two headings, (*a*) independent cords, (*b*) fixed cords. M. OG.

463. *Switchboards for Private Telephones.* **Mandroux.** (Électricien, 15. pp. 122–125, 1898.)—One act of plugging completes a connection in monocord boards. Economy is gained by using positive and negative call currents with a reversing key. The operator knows the goodness of each line by hearing her own call current (partly shunted). M. O'G.

464. *Series-Multiple Telephone Board.* **K. B. Miller.** (Amer. Electn. 10. pp. 32–33, 1898.)—A very clear diagram shows all connections. The repetition at each operator's section of all the jacks is necessary, and at each repetition the continuity of the line depends on a dusty contact. The connection of two subscribers detaches one of the twin wires from a capacity—that of the drop and switchroom wires. Both these evils are overcome in the Branch Multiple Board. M. O'G.

465. *Branch-Multiple Telephone Board.* **K. B. Miller.** (Amer. Electn. 10. pp. 82–83, 1898.)—One diagram of details and one of principles are explained. 'Branch' systems with 3 wires and auto-restoring drops are superseding the series board.
M. O'G.

466. *Telephone Line Protectors.* (West. Electn. 22. p. 124, 1898.) —The air-tight iron end-box of air-space cables bears for each wire a lightning arrester of two carbons separated by perforated mica 0·005″ thick. To guard against heavy currents each carbon encloses a metal ball imbedded in fusible wax which melts and short-circuits the guard. Besides, each circuit includes a german-silver heat-coil which melts an alloy and closes a "sneak-circuit," calling attention to the break. Also a 5-amp. fuse sealed in a wooden tube protects the cable. A round poletop box containing quicklime is shown. A carbon and ball arrester and heat-coils are used at each subscriber's connection. M. O'G.

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467. *Telephone Magnets.* (West. Electn. 22. pp. 131–132, 1898.) —Once the number of turns is fixed [electrical reasons not given] the core is designed to suit switchboard mechanisms. Up to six wires are spooled simultaneously to the same length and resistance and occupy the same relative position to the core. This "compartment" winding (by the Varley Duplex Co.) raises the insulation resistance from 50 megohms to 45,000. M. O'G.

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468. *Telephone Apparatus.* **H. P. Clausen.** (West. Electn. 22. pp. 127–129, 1898.)—General connections are shown, and each element in detail. Standard sizes, windings, gauge of wires and designs are also given. M. O'G.

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469. *Telephone Details.* (West. Electn. 22. pp. 120–121, 1898.) —At Fort Wayne, U.S.A., lead cables are encased in vitrified tiles bedded in concrete. Switchboard cords are protected with hard brass wire spirals and polished linen braid reinforced in the plug-heel. The chief operator may switch on to any subscriber to receive complaints. The board has a lightning arrester to each line. Any wire can be rapidly transferred from number to number at the permanent test terminals. M. O'G.

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470. *Wires for Telephony.* (West. Electn. 22. pp. 134–135, 1898.)—Wires are coloured to match oak, mahogany, etc. Twins are distinguished by one raised thread in the braid by feeling only. Communication with a stranded ship is noted. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MAY 1898.

GENERAL PHYSICS.

471. *Forms of Energy.* **A. Vaschy.** (Écl. Électr. 13. pp. 5–14, 1897.)—The author discusses the experimental properties of energy in its different forms, for example as kinetic and potential energy, heat energy, energy of elasticity, chemical energy, electric and magnetic energy. W. R. C.

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472. *Deformation of Metals.* **Mesnager.** (Comptes Rendus, 126. pp. 515–517, 1898.)—The lines which appear on the surface of iron subjected to deformation ("Luders' lines") have been found by Hartmann to occur on all metals. When the limit of elasticity is passed, there are generally two systems of curves crossing one another at constant angles, with possibly a third system of lines bisecting the former two. Below as well as above the limit of elasticity, the action of a weak acid will render these lines manifest when the metal is under stress. The two former sets of lines are bisected by the direction of the greatest tension. The formation of these lines is accompanied by slip of the material. A sketch is given of a mathematical theory of these phenomena. A. D.

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473. *Residual Torsion in Soft Iron.* **H. Bouasse.** (Comptes Rendus, 126. p. 585, 1898.)—In this note the author shows that the two laws announced by Moreau with respect to the residual torsion in soft iron are easily deduced from known facts. J. B. H.

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474. *Measurement of Torsional Angle of a Rotating Shaft.* **F. J. Jervis-Smith.** (Phil. Mag. 45. pp. 183–185, 1898.)—The method is as follows :—Two discs of insulating material are fixed at the ends of the shaft, and narrow slips of copper are attached to the discs at their circumferences, and to the shaft. Two brushes (single flat wires answer well) press on the edge of the discs,

the brushes are connected to an electric circuit, including a battery and a telephone. When the slips of copper are in the same plane, at each revolution of the shaft a click is heard in the telephone; but if while the shaft is rotating the disc at one end has an angular advance on the disc at the other end, due to torsion, no click will be heard, since the slips do not touch the brushes at the same instant. Now, in order to hear the click again, the brush-holder must be rotated through an angle equal to the angle of torsion, which is thus found.

The author has applied the method to find the torsional angle of an ergometer in which a solenoidal spiral spring is used instead of a shaft.

The couple due to any angle is found by fixing one end of the shaft and suspending known weights from a thin steel tape attached to a pulley of known radius keyed on to the shaft close to the disc. AUTHOR.

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475. *New Vacuum-Pump.* **J. Tuma.** (Wien. Akad. Sitzber. 106. pp. 473–480, 1897.)—In view of the constantly increasing experimental work connected with X-rays, instruments by means of which the required high vacua can be produced have become of great interest. The new mercury-pump illustrated and described in this paper is based upon the Sprengel-type, and fulfils the following important requirements:—(1) Simplest possible construction; (2) constant readiness for use and durability of parts attained chiefly by the exclusion of rubber; (3) facility of repair, even with ordinary glass-blowing experience; (4) high efficiency: a volume of half a litre can be exhausted in 30 minutes to Crookes' vacuum, and with continued exhaustion and heating, the highest at present attainable vacua are effected. These pumps are manufactured by the 'Glühlampenfabrik 'Watt'' in Vienna, and their cost is about 60 florins (about £4 10*s.* 0*d.*). S. G. R.

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476. *Decimal Time and Decimal Circular Measurements.* **J. de Rey-Pailhade.** (Comptes Rendus, 126. pp. 505–507, 1898.)—The author once more proposes to divide the day of 24 hrs. into 100 parts called *cé*, each of 14 min. 24 sec. (approximately one quarter of an hour), and to subdivide into deci, centi, milli, and demi-cés. The millicé would be 0·864 sec., the new unit for physical determinations. Similarly the whole circumference (4 R) is to be divided into 100 *cirs*, symbol κ, each of 3° 36′ or 4 grades; the dimicir would be 1·296″. November 2565·3 *cés* would signify, 25th of November at 65·3 *cés*. This system of notation has already been used by Tisserand and also by Aitken and Schaeberle. The agreement between time and longitude would simplify many calculations. The author has prepared tables for astronomical, geographical, and physical calculations based upon this system, and Mendizabal-Tamborrel has worked out the logarithms of these circular functions to 7 or 8 places. H. B.

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477. *Lines of Force and Equipotential Surfaces in Nature.* **G. M. Stanoiévitch.** (Comptes Rendus, 126. pp. 640–643, 1898.)—The similarity in form between diagrams of lines of force and equipotential surfaces in electrical and magnetic phenomena and certain natural patterns are pointed out and examples given.

Thin plates of non-axial and biaxial crystals, the section of an oak-tree just below a ramification, and also a deal plank with two knots, show patterns which bear a strong resemblance to well-known diagrams. The author thinks that the resemblance is not merely accidental, but is due to the action of definite forces.

R. S. C

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478. *Sailing Flight.* **Bretonnière.** (Revue Scientif. 9. pp. 33–40, 1898.)—The author considers that falcons, having fallen through a certain height, can describe a semicircle and then rise again to almost the same height, simply by changing their direction without moving their wings; and that, in a similar way, they can pass from a horizontal into an upward, and from a downward into a horizontal motion. Gulls are said to do the latter when they find their prey escape on approaching the water-level. The chief part of the paper deals with sailing flight against a uniform, horizontal wind, as to which he had been attacked by O. Chanute (Aëronautical Journal, 1897) and by Soreau, and which he explains in the following way:—A bird perched on a pole rises a little by the force of its wings, drifting backward with the wind, which it faces; it then shoots down at right angles to the wind and, facing the current again under a small angle, is borne to a greater elevation than it started from. This process may be repeated, the bird falling in a short steeper curve and rising again under a small inclination. The bird would thus appear to sail on a kind of breaker-wave. The author has not himself observed this sailing, but he quotes Basté and also Chanute as authorities for part of his hypothesis. For his calculations he makes use of Lilienthal's tables on the air-reaction against concave surfaces having a rise of arc equal to one-twelfth of the wing-breadth. But he regards the data as too uncertain. If a is the vertical and b_1 the horizontal component of the bird's velocity against a horizontal wind b_2, and $b=b_1+b_2$, then the hypotenuse c of a right-angled triangle, whose sides are a and b, would represent the descending air-current which the bird has to overcome and against which he sails under a small angle. For the descent of the bird, c would be an ascending current. This c is Bretonnière's "rafale relative." He does not share the opinion of most scientists that for the sailing bird a uniform air-current is equivalent to a calm.

H. B.

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479. *Psycho-Physical Law.* **Casslant.** (Revue Scientif. 9. pp. 171–176, 1898.)—The psycho-physical law expresses the relations between the intensity of a force (light, sound, heat) exciting our nerves and the resulting sensation. By experimenting with

lanterns provided with diaphragms of different apertures and with photometers, Ch. Henry has arrived at curves corresponding to the formula $S=K(1-e^{-\lambda i^m})$, in which S is the order of the sensation, i the apertures, and K, λ, m are the parameters of an exponential curve. The parameters vary for different individuals and different states of the eye. The experimenter started with the weakest source of light perceptible, and increased the light intensity gradually. A similar formula was obtained for the light reflected from differently coloured bands; the intensity comparison was made by covering the white field next to a coloured band with strips of gelatine until the difference disappeared. In the acoustic experiments, a watch was placed in a copper tube behind a diaphragm, between which and the watch cushions of cotton-wool and ebonite discs provided with apertures (radii from 1 to 4 mm.) were interposed. The same type of curve resulted. In the heat tests two vessels were filled with liquids of different temperatures, the hands, which were frequently changed, dipped in, and the one or other liquid cooled or heated until both had the same temperature. The temperature varied between +60° and −60° C. Two curves were obtained, one for heat and one for cold sensations, both starting from 15° C., and both again exponential, but with different parameters. Marius Blix has indeed assumed the existence of special nerves for heat and cold. In a certain sense, the other sensations also appear to be double, as if there were special sensations for light and darkness, for sound and silence. The time element, of course, enters into all three sensations, and the complete equation is $S=K(1-e^{-\lambda i^m})(1-e^{-\alpha i^n t})$. The formulæ are not well printed, so that it is difficult to distinguish the indices from the other letters, and the methods of procedure are not fully explained. H. B.

480. *Mathematical Conception of Space.* **A. Muller.** (Revue Scientif. 9. pp. 202–207, 1898.)—The title of this paper is misleading. Muller simply wishes to facilitate our forming ideas of astronomical magnitudes. For the solar system, he uses the diameter of the earth, 12,735 km., as unit of length, which he represents by 1 mm. For the nearest fixed stars, he further reduces the scale to one thousandth of that value. H. B.

481. *Photography of Ripples.* **J. H. Vincent.** (Phil. Mag. 44. pp. 411–417, 1897, and 45. pp. 191–197, 1898.)—The author first describes an apparatus for producing the photographs. The ripples are due to the agitation of the surface of the mercury by styles attached to tuning-forks. The light used is that of a Leyden-jar spark. It is rendered parallel before incidence on the mercury surface, and only that light which was reflected in a parallel beam was allowed to fall on the sensitive plate. The lens of the camera was provided with a very small stop.

The method is used to find the surface-tension of ordinarily

clean mercury. The paper then consists of a description of a dozen half-tone reproductions of ripple photographs. They chiefly illustrate in order the following :—(1) Fresnel's bands. (2) Moving elliptical interference-bands. (3) Meslin's bands. (4) Moving bands due to beats. (5) Ripples due to two styles vibrating with widely differing frequencies. (6) Lloyd's fringes. (7) Moving elliptical bands due to reflection. (8) Shallow circular mirror. (9) Spherical aberration. (10) Concave reflector. (11) Principal focus of circular mirror. (12) Diffraction.

Many other phenomena met with in wave-motion are described.

In the second paper similar results are given. The apparatus is slightly modified. The photographs illustrate the following :—(1) Ripples due to shaking of the sides of the trough by sound. (2) Shaking due to stamping with the foot on the floor of the laboratory. (3) Conjugate foci of circular reflector. (4) & (5) Abnormal foci. (6) Elliptical reflector. (7) Elliptical reflector with source at its centre. (8) Diffraction grating. (9) Zone plate. (10) The focal length of a zone plate is less for longer waves. (11) Refraction of ripples by a triangle of water. (12) Refraction of ripples by a series of circular drops of water.

AUTHOR.

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482. *Seismograph with Time Recorder.* **L. Pfaundler.** (Wien. Akad. Sitzber. 106. pp. 551–561, 1897.)—The author considers that the time recorders of seismographs leave something to be desired. Registration on a tape is out of question, since a paper-feed of 40 m. per day would be required to obtain legible records, representing seconds by spaces of 0·5 mm. He photographs the dial of a watch in the moment of the concussion. The watch is fixed in the door of the camera-box, and is illuminated by two small glow-lamps, whose circuit is closed by the shock. The contact apparatus consists of a vertical steel-rod ending above in a little brass cup holding a common marble. The upper end of the rod is surrounded by a funnel, closed at the bottom by a cap attached to a lever. The falling marble turns the lever, against whose journal, part of which is insulated, a contact-spring bears. This spring closes the circuit of three small accumulator cells. The marble rolls into a second trough, whose turning lever causes an alarm-bell to ring, until the observer puts the ball back into its cup on the steel rod. The observer also changes the dry plate, after which a fresh time-record can be made. The watch has to be wound up, but otherwise the apparatus requires no attendance. The four different parts of the apparatus are connected by wires only, and may be in different rooms. The drawback of the device is that two consecutive automatic time-records cannot be obtained, so that, of rapidly following concussions, only the first will be timed. This might be remedied, *e.g.*, by making the photographic plate revolve slowly. Pfaundler does not desire to complicate his device, however.

H. B.

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483. *Propagation of Earthquake Oscillations.* **M. P. Rudzki.** (Akad. Wiss. Cracow, pp. 354–355, 1897.)—This is a mathematical deduction, given in abstract only, based upon A. Schmidt's hypothesis that the propagation of earthquake oscillations is a decreasing function of the earth radius. The apparent rate with which the waves spread on the earth surface is infinite at the epicentre; that is to say, all points near the epicentre are shaken at the same moment. Further away from the epicentre, the rate decreases in all directions, and attains its minimum at a certain distance; the equation for this circle has been deduced. Beyond that circle, the rate increases again. The diameter of the circle depends upon the depth of the earthquake origin. When the depth is insignificant, the circle will be represented by the epicentre; the greater the depth, the larger the area of decreasing apparent rate of surface propagation. When the earthquake originates in the centre of the earth, there will be no area of decreasing or increasing rate of propagation; the rate will be infinite everywhere, since all points of the surface will feel the concussion simultaneously. H. B.

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484. *Lecture Experiment on Air-Pressure.* **E. Warburg.** (Berlin. Phys. Gesell. Verh. 17. pp. 21–22, 1898.)—That the air-pressure decreases at higher elevation can easily be demonstrated in the following way:—An ordinary Argand gas-burner, connected with the gas-pipe by a long rubber tube, is suspended so that it can be raised by 4 m. In the higher position the flame ought to be larger, since the light gas is less influenced by gravity than the heavier air. The difference is not striking enough, however. But when the gas pressure is first reduced, with the help of a Mariotte bottle, to about 10 mm., the flame will on the table appear blue, and become larger by 30 per cent. and luminous on raising the burner. H. B.

LIGHT.

485. *Interferential Spectroscope.* **Ch. Fabry** and **A. Perot.** (Comptes Rendus, 126. pp. 331–333, 1898.)—The instrument has been previously mentioned in Abstract No. 23, Jan. 1898, and the present paper is devoted to a more complete description. The interference bands produced between two silvered glass surfaces adjusted to exact parallelism are observed, their form in this case being circular. Provision is made for varying the distance between the two surfaces without disturbing their parallelism, the separation being read off directly on a half-millimetre scale. Fine adjustments are obtained by the flexure of a plate of steel caused by a column of water in an indiarubber tube. Comment is made upon the conditions necessary for the best results, upon the thickness of the silvering on the two glass plates, and the necessity of using a small source of light. A single plate of glass with both its faces silvered may be employed, one advantage of this being that, for the same dispersion, the bands are more separated, and therefore more easily observed. A serious disadvantage is the invariability of the difference of path of the interfering pencils, and also the great care necessary to work the two surfaces exactly parallel to each other. C. P. B.

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486. *Spectral Lines.* **A. Perot** and **Ch. Fabry.** (Comptes Rendus, 126. pp. 407–410, 1898.)—The authors have used their interferential method of comparing wave-lengths (Ann. de Chim. et de Phys. Dec. 1897) for a study of the spectral lines of some metals. The thallium line they find is composed of one principal radiation and two feeble radiations of longer wave-lengths and of approximately equal intensities. The intervals between the wave-lengths of the principal and the feeble rays are 3×10^{-6} and 21×10^{-6} of the principal wave-length. The green mercury band they also find to be triple, the feeble components being of greater wave-length than the principal component. The intervals between the principal and feeble components are 17×10^{-6} and $1{\cdot}5 \times 10^{-6}$ of the principal wave-length. The green band of cadmium is found to be double, the feeble ray being of shorter wave-length $\left(\frac{\Delta\lambda}{\lambda} = -5 \times 10^{-6}\right)$. The blue cadmium band is triple, the two feeble radiations being equally distant on opposite sides of the principal band, and for both $\frac{\Delta\lambda}{\lambda} = 17 \times 10^{-6}$. J. B. H.

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487. *Dissociation Spectra of Fused Salts.* **A. de Gramont.** (Chem. News, 77. pp. 28–29, 1898.)—In continuation of a previous paper in the Ann. Chim. Phys., ser. 7, vol. x. Feb. 1897, the author

gives the measurement of the chlorine lines in the chlorides of Na, Li, K, Cd, and Zn, all of which easily showed the haloid spectra when not effaced by brilliant metallic lines. The different groups are characteristic from an analytical point of view, and are sharper in the melted compounds with the condenser-spark than in tubes with the free element. With only 0·0001 grm. of chlorine the groups Clγ and Clζ were still visible. The nomenclature of M. Salet (1873) is used throughout the paper.

Bromine.—M. Salet's multiple lines Br β, γ, δ, and ϵ, are found by the author to be single—while Br η and θ are much brighter than Salet described. The most characteristic lines in melted salts are Br ν, μ and ζ, in order of importance.

Iodine is richer in lines than Cl or Br, especially in orange-red. The most sensitive are Iη, Iμ, and Iζ_2 (546·6). S. G. R.

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488. *Ultra-Violet Spark-Spectra.* **F. Exner** and **E. Haschek.** (Wien. Akad. Sitzber. 106. pp. 494–520, 1897.) (For previous papers see Phys. Soc. Abstracts, 1896, No. 449; 1897, Nos. 73, 301, 302, 526, and 653, and Science Abstracts, No. 365).—For K, Na, Ba, and B, compounds such as K_2CO_3, Na_2CO_3, Ba $(OH)_2$, and B_2O_3, fused on gas carbon terminals, had of necessity to be used instead of the elements. Photographs could not be taken on account of the interference of the carbon bands. 59 lines (between λ=4505·55 and 2549·6 AE) were measured for K, only 5 lines (3303·13 – 2680·3) for Na, 168 lines (4726·64 – 2255·0) for Ba, and 8 lines (3451·4 – 2266·47) for B.

Iron.—2270 lines were measured and photographed in the ultra-violet between λ=2068·25 and 4736·96 AE. Whilst Kayser and Runge found in their iron spectrum many hundred lines belonging to impurities such as Ni, Co, Cr, Mn, the authors have only found 14 foreign lines, attributable to traces of Ca, Mg, Ba, Mn, Cu, and Si. This exceptionally pure iron had been prepared in a pulverulent form by Prof. H. Weidel, and was condensed into a coherent mass by a pressure of 1000 atmospheres in a special steel apparatus.

S. G. R.

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489. *Röntgen Rays and Germination.* **Maldiney** and **Thouvenin.** (Comptes Rendus, 126. pp. 548–549, 1898.)—The rays are found to have a remarkable influence in promoting germination. *Convolvulus arvensis* seeds, exposed to the rays for about an hour daily, germinated on the third day; these sheltered from the rays, but otherwise similarly situated and at the same temperature, germinated on the sixth day. *Lepidum sativum*, 49 hours and 6 days. *Panicum miliaceum*, 6 days and 16 days. The rays were from a Chabaud tube, 8 amperes, at 8 cm. from the seeds. There was no heating-effect due to the rays. The chlorophyll was absent at first just as under ordinary circumstances. A. D.

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490. *Röntgen Rays and Osmosis.* **H. Bordier.** (Comptes Rendus, 126. pp. 593–596, 1898.)—The influence of Röntgen rays on osmosis was investigated by allowing the rays to fall on the animal parchment membrane of an osmometer which had a solution of sugar or salt inside, and was placed in a vessel of water. The rate of rise of the liquid in the osmometer tube was noted when Röntgen rays were present, and also when absent; and in every case the rate of rise was diminished by the rays, the diminution amounting to from 25 to 50 per cent. The author thinks this may possibly lead to an explanation of some of the observed therapeutic effects produced by the rays. J. B. H.

491. "*Secondary Rays*" *from Air.* **G. Sagnac.** (Comptes Rendus, 126. pp. 521–523, 1898.)—The secondary rays produced by transformation of Röntgen rays on impact upon a solid are produced not only at the surface of the impact, but also at that of exit. In the case of gold the thickness of the metal whence these rays come is about $0{\cdot}5\ \mu$; in that of aluminium about 1 mm., 2000 times as great. In such a substance as air the two layers overlap, and the secondary radiation from the air is in all directions; but the secondary rays from air are less penetrating than the direct Röntgen rays of which they are the transformation. The phenomenon is not analogous to light scattered by tobacco smoke, but to a beam of light sent through a solution of fluorescein. A. D.

492. *Diffraction and Photographic Network Screens.* **Ch. Féry.** (Comptes Rendus, 126. pp. 333–335, 1898.)—The spreading of each point of light into the shadows is not due to diffraction; for with a camera-length of 30 cm. and a network screen at 3 mm. from the sensitive plate, the fringes could not be wider than 0·03 mm., and would disappear in the reduction and intensification; and further, all the fringe-effects would disappear if the source of light instead of being a point, was 3 mm. across, and would blend into a general penumbra effect. A series of experiments is described, confirming these conclusions. To get the black diffraction-cross it is necessary to set the screen at 15 mm. from the sensitive film, and to use a source of light 0·5 mm. in diameter. When the black cross is at its maximum, $a^2/4=e\lambda-e^2\lambda/F$, where a is the width of a clear space in the screen, e the distance between the screen and the sensitive plate, F the camera-length, and λ the wave-length; or, approximately, $e=a^2/4\lambda$, so that the distance between the screen and the plate, in order to produce the most marked black cross, is independent of the camera-length and of the diaphragm, conditions which nevertheless do affect the clearness of the definition. A. D.

493. *Action of Thermic Poles on Photographic Plates.* **A. Guébhard.** (Comptes Rendus, 126. pp. 589–592, 1898.)—This paper

contains an investigation of some phenomena described by the author in a former paper (C. R. 125. pp. 814–819, 1897), connected with the action of thermic poles on photographic plates when in the developing bath. In certain positions of the plate a black spot on the plate would show where the hot pole had acted, while in other positions the spot would be white. The plates also showed a striated appearance, the striæ being along the lines of flow of heat. The author finds that the appearances are fully accounted for by the convection currents. The black spots correspond to the places where the circulatory movement of the liquid tends to bring the molecules against the film, and the white spots to the places where the movement tends to detach them from it.

J. B. H.

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494. *Radiation Phenomena in a Magnetic Field.* **P. Zeeman.** (Phil. Mag. 45. pp. 197–201, 1898.)—This is a preliminary account of measurements of the separation of the outer components of the Zeeman triplet. The results, so far, show that for different substances in the same field the interval (in wave-lengths) is of the same order of magnitude, and certainly not directly dependent upon the atomic weight. But the variation with wave-length seems more complicated than it would be on Larmor's hypothesis.

The results for zinc are:

λ.	Distance between components in $\frac{1}{100}$ millim.	Scale of negative.	Order of Spectrum.
4811	18·6	1 millim. =4·41 A.U.	2
4722	20·7		
4680	25·1		
3345	Imperceptible	1 millim. =2·94 A.U.	3
3303	....		
3282	0		

In both sets $H=32.10^3$. It is noticeable that the first three lines result from Kayser and Runge's *second* subordinate series for $n=3$ (Wied. Ann. 43. p. 394). The second three belong to the first set for $n=4$.

Results for cadmium, copper, and tin are also given. The author intends to repeat the experiments with an improved apparatus.

G. B. M.

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495. *Absorption of Light in Crystals.* **J. Ehlers.** (Neues Jahrbuch für Mineralogie, Geologie und Paleontologie, 11. 1897.)—The experiments relate to plates of the following crystals, cut as indicated.

Tourmaline.—One plate parallel to the axis, one perpendicular to it, one at 47°, and one at 43° 30′.

Smoky quartz.—One parallel to axis, one perpendicular to it, one at 30°, and one at 60°.

Double sulphate of copper and cobalt.—Two perpendicular to the

bisectors of the axes, one parallel to the plane of the axes, one at 14° to the first bisector.

Double sulphate of potassium and cobalt.—As in last; the fourth, however, being at 22° 30′.

Double sulphate of ammonium and cobalt.—One plate perpendicular to the first bisector, two, of different thicknesses, perpendicular to the second.

Using König's spectrophotometer, the author determines for both ordinary and extraordinary rays the index of refraction for wave-lengths ranging from 0·486 μ to 0·687 μ, and also the coefficient of absorption and its variation with the incidence. The conclusion arrived at is that in the plane of crystallographic symmetry there are two directions of maximum and minimum absorption, at right angles to each other, but not related in any simple way to the axes of symmetry. G. B. M.

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496. *Determination of the Sense of a Circular Vibration.* **A. Cotton.** (Journ. de Physique, 7. pp. 81–85, 1898.)—Two methods are explained:—(I.) Take a nicol which only allows to pass vibrations OP in the plane of its principal section; superpose a Fresnel parallelopiped with its plane of symmetry OA distant 45° from OP. This gives circular vibrations the sense of which is that in which an observer receiving the emergent ray would turn OA through 45° to make it coincide with OP. (II.) Between a nicol and a *circular* polariser (or analyser) put a plate of Iceland spar cut perpendicular to the axis. Near the centre of the ring-system thus produced are seen two black spots, the line joining which makes 45° with the principal section of the nicol, on one side or the other, according to the sense of the circular vibration. The author has confirmed Cornu's specification of the sense of the Zeeman rotatory effect observed along the lines of force.

G. B. M.

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497. *Calcite and Glass Nicol Prisms.* **C. Leiss.** (Berlin. Akad. Sitzber. 40. pp. 901–904, 1897.)—Iceland spar has become so rare, that the nicols have had to be replaced by Nörrenberg sets of glass plates in saccharimeters, microscopes, and other apparatus. Since 1884, attempts have also been made to substitute crystals of nitre and potassium chromate for calcite. Plates of these salts are fixed between two wedges of glass; but good crystals of large size and suitable cements are difficult to obtain, and the colour of the chromate is objectionable. Leiss makes the second half of a nicol of glass of the same shape and refractive and dispersive power as calcite. As perfect agreement cannot as yet be realised, however, he recommends such compound nicols more as polarisers than as analysers. In his analyser, the extraordinary ray is very slightly deflected, so that the object appears to oscillate a little when the analyser is turned. The paper does not give any particulars.

H. B.

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498. *Photometry of Mirror Projectors.* **A. Blondel** and **J. Rey.** (Comptes Rendus, 126. pp. 404–407, 1898.)—The authors deduced from theoretical considerations that the brilliancy of any point of the surface of the mirror of a mirror-projector of the form due to Mangin is practically constant, each point being considered as a source of light, and its brilliancy being measured in the direction of the optic axis of the mirror. They have now tested this experimentally, and find that the brilliancy is constant except at the edges of the mirror and the central portion which is hidden by the negative carbon. To determine the brilliancy at any point of the surface, a sheet-iron screen was introduced a short distance in front of the projector so as to cut off all the rays except those coming from a small area surrounding the point. These rays passed through a small hole in the sheet-iron screen, and formed an image of the crater on a photometer-screen interposed at some distance. The illumination at the centre of this image was measured, and the brilliancy at the point of the mirror calculated. By finding the brilliancy of each zone of the mirror the total candle-power of the projector is easily deduced. Thus the experimental determination of the candle-power of search-lights can be performed without leaving the laboratory. J. B. H.

499. *Aerial Graphoscope.* **E. S. Bruce.** (Soc. Arts Journ. 46. pp. 201–210, 1898.)—A lath is rotated about its centre in its own plane, and a picture projected upon it by a magic lantern. The apparatus illustrates persistence of vision, and may be used for testing it quantitatively. Three tables of numerical results are given. The inventor suggests that the apparatus may be used for stage effects such as the dagger in 'Macbeth.' G. B. M.

HEAT.

500. *Fusibility of Foundry Iron.* **T. D. West.** (Eng. 65. pp. 287–288, and pp. 319–320, 1898.)—The author has, from a practical standpoint, carefully tested the fusibility of grey and chilled irons. He does not give the melting-points nor the latent heats of fusion (perhaps such things are useless from the varying conditions of an experiment), but finds that chilled iron when placed in a cupola takes distinctly *less time* to melt than iron which has been cast in sand. The tests are not confined merely to the determination of fusibility, but the chemical changes due to remelting, the shrinkage and contraction on casting, are also studied. The experiments show that chilled iron gives a softer iron on remelting than grey iron. A. Gs.

501. *Measurement of High Temperatures.* **D. Berthelot.** (Comptes Rendus, 126. pp. 410–412, 1898.)—The principle of the method employed depends on the fact that if the density of a gas is diminished by a certain fraction either by diminution of pressure or by rise of temperature, the refractive index of the gas takes the same value in the two cases. A beam of light is divided, one half traversing a tube of air in which the pressure can be varied and measured, the other half traversing a tube of air which can be heated electrically by a coil of wire surrounding the tube; the two halves are then recombined, so as to give interference-fringes. The pressure of gas in one tube is varied so as to counterbalance any motion of the interference-bands due to rise of temperature in the other, and the rise of temperature is then calculated from the variation of pressure. To eliminate the variations of temperature along the tube a differential method is employed, by which only the influence of a certain length of the middle portion of the air-column in which the temperature is constant, is measured. An accuracy of 1° up to the temperature of fusion of gold is claimed.

J. B. H.

502. *Measurement of Thermal Conductivity in Crystals.* **W. Voigt.** (Journ. de Physique, 7. pp. 85–90, 1898.)—Suppose x, y, z, the directions of the axes of thermal symmetry in a crystal, are known. A plate is cut parallel to the plane xy, and in the shape of a rectangle whose sides are parallel to the bisectors of the angles contained by x, y. The rectangle is then bisected along a line parallel to two of its edges, and the two halves are cemented together after turning one of them through 180°. The plate is now covered with a mixture made by adding to elaidic acid about $\frac{1}{4}$ of its weight of de Sénarmont's compound of wax and turpentine. When the plate is warmed by a source of heat, symmetrical with respect to the central line, isothermal lines are produced at the edge of that part of the mixture which is melted. The isothermals

meet on the central line at a constant angle ψ, and the principal conductivities, λ_1, λ_2 in the plane xy are connected by the relation

$$\lambda_1/\lambda_2=\left(1\mp\tan\frac{\psi}{2}\right)\Big/\left(1\pm\tan\frac{\psi}{2}\right).$$

The method of isothermals may also be usefully applied to determine the relative conductivities of isotropic bodies—*e. g.*, bad conductors or rare substances. G. B. M.

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503. *Transmission of Radiation by Gases.* **C. F. Brush.** (Phil. Mag. 45. pp. 31–42, 1898.)—Dulong and Petit concluded from their experiments that the rate of cooling due to the presence of a gas at pressure p varies as p^a, where a is a constant less than 1 which differs for each gas. The author's observations show that this can be approximately true only when the cooling occurs in a relatively large space and the pressure is not less than, say, $\frac{1}{50}$ atmosphere. He placed a thermometer-bulb in the middle of a reservoir whose sides were kept at 0°, and observed its times of cooling from 15° to 10°, from 9° to 6°, from 6° to 4°, and from 3° to 2°; the reciprocals of these times (which were taken as the measure of the rates of cooling) were then plotted on a diagram with pressures for abscissæ. If Newton's law were true, the four lines so drawn for any gas would be coincident, since the time of cooling from one temperature to another would be proportional to the logarithm of the ratio of these temperatures, and this ratio is the same for all the pairs of temperatures taken. Such coincidence was, however, observed in only one or two cases, and then only at extremely low pressures; in general the curves lay in order one below the other, that for the 15°–10° range being the highest.

Experiments were made with air, carbon monoxide, ethylene, hydrogen, and carbon dioxide, and two forms of reservoir were employed—one fairly large, and the other little larger than the enclosed thermometer. With the larger reservoir the curves were convex upwards till about $\frac{1}{20}$ atmosphere, were then parallel to the p-axis or slightly concave upwards till about $\frac{1}{500}$ atmosphere, and then bent downwards again with exceeding rapidity. With the small bulb the curves were quite changed in shape, being nearly straight or slightly concave upwards till about $\frac{1}{50}$ atmosphere and then bending quickly downwards. Admixture of CO_2 with H was found to interfere very greatly with the cooling power of H. R. E. B.

ELECTRICITY.

504. *Magneto-Optic Phenomena.* **C. H. Wind.** (Phys. Rev. 6. pp. 43–51, 1898.)—The writer proposes to show how, starting from Maxwell's field equation, we may, by assuming a certain relation between the electric force and electric current in a magnetic field, explain mathematically both the Hall effect and the Kerr effect. First, assuming an isotropic field in which no external magnetic force acts, any disturbance is represented by

$$A\epsilon^{-\frac{2\pi i}{T}(t-R[x\sin\phi+\eta\cos\phi])}=AP.$$

The fundamental equations in this case are, in the usual notation,

$$\text{Div. }\mathbf{E} = 0 \quad \ldots\ldots\ldots\ldots \quad \text{I.}$$

$$(\mathbf{E}_n)_1 = (\mathbf{E}_n)_2, \quad \ldots\ldots\ldots \quad \text{II.}$$

n being the normal to a surface of separation of two media :

$$\text{Rot. }\mathbf{H} = 4\pi\mathbf{E} \quad \ldots\ldots\ldots \quad \text{(A)}$$

$$\text{Div. }\mathbf{H} = 0. \quad \ldots\ldots\ldots\ldots \quad \text{III.}$$

$$(\mathbf{H}_n)_1 = (\mathbf{H}_n)_2 \quad \ldots\ldots\ldots \quad \text{IV.}$$

$$\mathbf{H}_{h1} = \mathbf{H}_{h2}, \quad \ldots\ldots\ldots \quad \text{V.}$$

h being a line in the surface of separation.

The electric force satisfies

$$\text{Rot. }\mathbf{F} = -\frac{d}{dt}.\mathbf{H} \quad \ldots\ldots \quad \text{(B)}$$

$$(\mathbf{F}_h)_1 = (\mathbf{F}_h)_2 \quad \ldots\ldots\ldots \quad \text{VI.}$$

and

$$\mathbf{E} = p\mathbf{F}, \quad \ldots\ldots\ldots \quad (37)$$

where p is a known complex constant.

The question then arises what modification must be made in these equations when there is an external magnetic force **N**. It is proposed, in order to solve this problem, to leave equations I. and II. unaltered—to understand (A) and III., IV., V., as merely defining the vector **H**. There remain only B, VI., and (37). It has hitherto been usual to write

$$\mathbf{F} = \frac{1}{p}\mathbf{E} - q[\mathbf{NE}], \quad \ldots\ldots\ldots \quad \text{(C)}$$

[**NE**] denoting the vector product of **N** and **E**, and q denotes a *real* constant. Our author proposes to make q a *complex* constant, which he says completely explains the phenomena in a medium which is magnetised in the plane of incidence. Substitute the value of **F** given by (C) in B, and apply I. Then B becomes

$$\frac{1}{p}\text{Rot. }\mathbf{E} + q\mathbf{N}\frac{\partial}{\partial z}\mathbf{E} = -\frac{d}{dt}\mathbf{H}, \quad \ldots\ldots \quad (\text{B}a)$$

the axis of z being the direction of **N**. Then he finds

$$\alpha = -\mathrm{R}\cos\phi\left(\frac{1}{p}b - q\mathbf{N}a\cos\phi\right)\mathrm{P},$$

$$\beta = \mathrm{R}\left(\frac{1}{p}a + q\mathbf{N}b\cos\phi\right)\mathrm{P},$$

$$\gamma = \mathrm{R}\sin\phi\left(\frac{1}{p}b - q\mathbf{N}a\cos\phi\right)\mathrm{P},$$

a and b being two new constants. In result he obtains six sets of equations as follows :—

$$\mathrm{R}_0^2 = \frac{4\pi p}{\partial}, \qquad \text{(D)}$$

in which $\partial = -\frac{2\pi i}{\mathrm{T}}$;

$$\tfrac{1}{2}pq\mathbf{N} = \mu\,; \qquad \text{(E)}$$

$$\mathrm{R} = \mathrm{R}_0(1 \mp \mu i\cos\phi)\,; \qquad \text{(F)}$$

$$\left.\begin{aligned} u &= a\cos\phi\mathrm{P} \\ v &= \pm\, ia\mathrm{P} \\ w &= -a\sin\phi\mathrm{P} \end{aligned}\right\}; \qquad \text{(G)}$$

$$\left.\begin{aligned} \mathrm{X} &= \frac{a}{p}(\cos\phi \pm 2\mu i)\mathrm{P} \\ \mathrm{Y} &= \pm\, i\frac{a}{p}(1 \pm 2\mu i\cos\phi)\mathrm{P} \\ \mathrm{Z} &= -\frac{a}{p}\sin\phi\mathrm{P} \end{aligned}\right\}; \qquad \text{(H)}$$

$$\left.\begin{aligned} \alpha &= \pm\, i\mathrm{R}^0\cos\phi(1 \pm \mu i\cos\phi)\mathrm{P} \\ \beta &= \mathrm{R}_0\frac{a}{p}(1 \pm \mu i\cos\phi)\mathrm{P} \\ \gamma &= \pm\, i\mathrm{R}_0\sin\phi(1 \pm \mu i\cos\phi)\mathrm{P} \end{aligned}\right\} \qquad \text{(K).}$$

The equations (G), (H), (K), (D), (E), and (F) contain M. Wind's solution of the problem. S. H. B.

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505. *Contact Electrification.* **A. Coehn.** (Annal. Phys. Chem. 64. 2. pp. 217–232, 1898.)—Experiments on insulating solids and liquids, made by Faraday, Nernst, Drude, and the author among others, show that the bodies of high dielectric capacity assume a positive charge in contact with insulators of a lower dielectric capacity. This is probably a universal law, which sheds much light on the process of contact electrification itself. The case of conducting bodies has already been dealt with by Nernst's ionic mobility theory. It is interesting to note that diamond, which is positive with respect to all other solids, has probably a high dielectric capacity, as indicated by its high refractivity. E. E. F.

506. *Electrical Properties of Freshly Prepared Electrolytic Gases.* **J. S. Townsend.** (Phil. Mag. 45. pp. 125–151, 1898.)—The experiments which are described in this paper deal with the oxygen and hydrogen which are evolved electrolytically from dilute solutions of sulphuric acid and caustic potash. These gases carry with them electric charges which, to a large extent, remain in the gas after it has been bubbled through sulphuric acid or other solutions, or after the gas has been passed through glass-wool. The gases evolved from the sulphuric-acid electrolyte carry a positive charge, and those which are evolved from the caustic-potash electrolyte carry a negative charge. When the charged oxygen or hydrogen is moist a cloud is formed, which can be removed by passing the gas through sulphuric acid or a calcium chloride tube, but when the gas is passed through water the cloud appears again. Various experiments were performed to show that the drops which constitute the cloud are formed round the carriers of the electric charge. Thus, if the moist gas be passed along a horizontal tube, the charge in the gas will gradually be removed, whereas if the gas be dry the rate of loss of charge is very much slower. In the former case the cloud which is formed falls in the tube and carries with it the charge.

Both the density of electrification and the number of drops in the cloud are increased when the temperature of the cell from which the gases are evolved is increased. The relation connecting the weight of the cloud and the charge on the gas was found by the following method. The gas from the cell was passed through water at a known temperature. It thus acquired a known quantity of moisture and also a cloud. The stream of gas was kept uniform (by sending a steady current through the electrolyte) and, after leaving the water, was passed through a set of three bulbs containing sulphuric acid. By this means both the moisture and cloud were removed; and by finding the increase of weight of the bulbs and subtracting from it the calculated weight of the moisture, the weight of the cloud was obtained. As the gas escaped from the bulbs it entered an insulated inductor connected to a pair of quadrants of an electrometer, so that the charge on the gas could be determined by the deflection on the electrometer scale. The sulphuric-acid bulbs were also insulated, and connected to the quadrants so as to find the rate at which they acquired a charge as the stream of gas passed through them. By this means the density of the electrification of the gas entering the bulbs was found, being equal to the sum of the charges acquired by the bulbs and the inductor divided by the volume of the gas. Both the weight of the cloud per c. c. and the corresponding electrification were thus determined; and it was found that when the temperature of the electrolyte was raised, that both these quantities increased in such a way that their ratio remained constant.

This result was made use of to determine the charge on each of the drops in the cloud. The size of the drops was obtained by observing the rate at which the cloud fell, and the weight of

each calculated. The number of drops per c. c. in the cloud was found by dividing the weight of the drop into the weight of the cloud per c. c.; the charge on each carrier could therefore be found, since the total charge and the number of carriers was known. The charge on each of the oxygen carriers was thus found to be about $3 10^{-10}$ electrostatic units.—Experiments were also carried out to find the size of the carrier on which the charge resides when the water has been evaporated from the drop by drying the gas. The body which is left is too small to move appreciably under the force of gravity, so that its size was obtained by finding the velocity with which it moved through the gas when acted on by an electromotive force. Thus in the case of the oxygen from the sulphuric-acid electrolyte, the radius of the drop in the cloud when the gas is saturated with moisture is $6{\cdot}815^{-5}$ centimetres, and when the gas is dry the size is reduced to $1{\cdot}110^{-6}$ centimetres. That the carriers on which the charge resides, when the gas is dry, are large compared with molecules, was also proved by showing that they diffused very much slower than a gas. A series of experiments made with the hydrogen and chlorine which are given off when a current is sent through a hydrochloric-acid electrolyte, showed that in this case the hydrogen carries a positive charge and the chlorine a negative charge. It was found that the charge on the hydrogen did not remain constant when carbon electrodes were used, but that, when the chlorine had dissolved in the acid and surrounded the negative electrode, the charge on the hydrogen became negative. This effect does not take place when platinum terminals are used, the charge on the hydrogen remaining always positive. AUTHOR.

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507. *Spark Discharge.* **R. Swyngedauw.** (Écl. Électr. 14. pp. 326–335, 1898.)—This paper forms a detailed reply to the criticisms of Jaumann on the author's researches. The main point at issue is as to whether the statical sparking potential between two knobs is the same as the sparking potential corresponding to rapid variations of the charges. This question is answered in the affirmative by the author, and is negatived by Jaumann. The latter has described experiments which at first sight appear to support his conclusion, but which the author shows may be interpreted so as to be in agreement with his own theory. Then follows a detailed examination of some of Jaumann's experiments: he has asserted that the process of charging by means of an influence-machine cannot be regarded as statical or gradual, on account of the oscillations which take place in the charges. The author has carried out a large number of experiments, using the following three methods:—(1) Connecting the knobs of the discharger to the plates of a plane charged condenser, and then slowly increasing the distance between the plates until sparking between the knobs takes place. (2) The knobs being maintained

at a constant P.D., the distance between them is gradually reduced until sparking occurs. (3) The knobs are connected to the coatings of a large leyden, which is then slowly charged by an influence-machine. Using knobs of different diameters and with different sparking-distances, the author finds very close agreement between the results furnished by the three methods. Jaumann's results, on the other hand, exhibit wide divergences. The author is of opinion that the discrepancy between his own results and those of Jaumann, is mainly due to the fact that the latter had his electrodes placed in a closed vessel. The author had himself tried this plan, but found, contrary to his expectation, that it was impossible to obtain consistent results unless the air surrounding the knobs were violently agitated. He supposes that, on account of the comparative immobility of the air modified by the passage of the spark, the sparking potential with enclosed knobs is altered. Hence the arrangement is one to be avoided. All the author's later experiments, which give perfectly consistent results, were carried out in free space.—There is only one exception to the general rule that the sparking potential is the same whether gradually or suddenly applied, viz., when the discharger is exposed to ultra-violet radiation. In this latter case, the lowering of the sparking potential is a steadily-increasing function of the rate of variation of the P.D. between the knobs of the discharger. A. H.

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508. *Spectrum of Kathode Rays.* **Birkeland.** (Comptes Rendus, 126. pp. 228–231, 1898.)—This is a reference to a note by the author in the Comptus Rendus for Sept. 28, 1897, that magnetically-deviated kathode rays are dispersed into a spectrum-like bundle, and to Thomson in Phil. Mag. for Oct. 1897. The appearances of these spectra vary when the kathodes are changed, and vary more with the construction than with the material of the kathodes; but with precautions described, uniform results may be obtained. The spectrum is then obviously a line-spectrum; but these lines are found to widen apart more or less when the capacity and the resistance of the circuit are increased. The author concludes that the kathode emits (1) intermittent discharges regulated by conditions exterior to the tube (difference of potential between the anode and the kathode, capacities and conductivities in the neighbourhood of the kathode), these discharges giving rise to the kathode rays; and (2) similar discharges regulated by the conditions within the tube, which discharges give rise to the phenomena of stratification. A. D.

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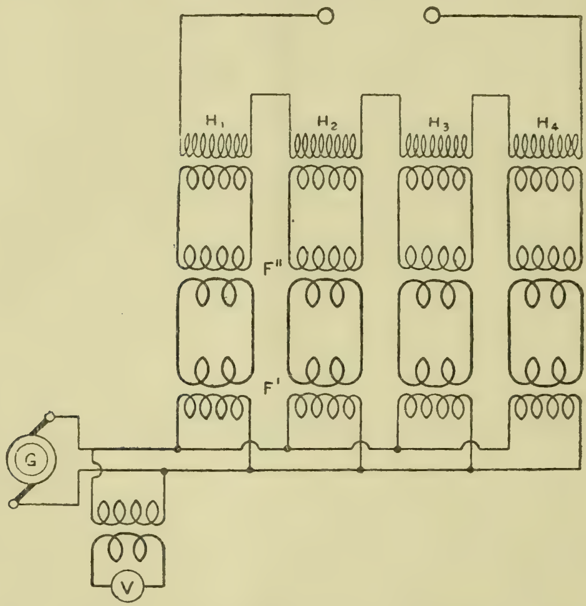
509. *Discharge at* 150,000 *Volts.* **C. P. Steinmetz.** (Elect. World, 31. pp. 294–295, 1898.)—This is an investigation of the phenomena taking place during a disruptive discharge at very high voltage in a circuit of sufficient power to maintain an arc. A series of photographs are taken differing from each other in

length of exposure. As discharge-terminals there are used two half-inch brass spheres, separated from each other by 14 inches, and in some cases by 15 inches. The camera was focused on the discharge-terminals and the cap taken off the lens; the generator-switch was closed to start the disruptive discharge, and the generator-field switch was opened after the discharge had lasted the desired time.

The high voltage was obtained by means of a series of transformers arranged as in the accompanying diagram.



From a series of twelve interesting photographs, the author draws the following conclusions:—

(1) The discharge of a high-potential circuit is always oscillating; even if sufficient power is behind the circuit to maintain an arc; and a number of successive oscillations are necessary to weaken the disruptive strength of air sufficiently to maintain an arc. Thus the dielectric strength of air is not reduced to zero by a single electrostatic discharge or rupture, but, on the contrary, is still sufficiently high to force the next oscillation into a somewhat different path.

(2) An arc impelled by extremely high voltage, and with considerable power behind, is in continuous and very rapid eddying motion, flaring upward, due to the upward draught of heated air. It never extinguishes itself, but frequently appears to jump across space by what seems to be bifurcation. W. G. R.

510. *Kathode Rays in an Alternating Field.* **H. Ebert.** (Annal. Phys. Chem. 64. 2. pp. 240–261, 1898.)—Schmidt's interesting experiments on the deflection of kathode rays in obedience to the impulses of a changing electrostatic field were repeated by the author in a manner such as to make the kathode-ray circuit quite independent of the alternating circuit. The author used a high-frequency alternator transformed to 1500 volts effective voltage by means of a Siemens spark-inductor. The secondary current was communicated to a small plate-condenser embracing a Braun phosphorescence-tube just behind the diaphragm. The deflections of the line of light on the screen were studied by means of a rotating mirror. They were perfectly sinusoidal. These deflections were not in this case due to a displacement of the origin of the rays on the kathode, since that origin was 30 cm. off behind a metallic diaphragm. Moreover, on removing the condenser-plates a few cm. from the tube, the deflections ceased. They could be restored by substituting glass or ebonite for the air between the plates and the tube. The deflections are not due to the magnetic forces of the electric displacement currents, but they are strongly influenced by the charges on the tube-walls. Their cause must be sought for in the bending experienced by the kathode rays on coming into contact with the dark spaces created by the electric oscillations inside the tube. E. E. F.

511. *Action of Magnetic Force on Vacuum Discharge.* **Birkeland.** (Comptes Rendus, 126. pp. 586–589, 1898.)—The author placed a cylindrical Crookes tube coaxially with a straight cylindrical electromagnet, and investigated the influence of magnetic force on the discharge, by slowly moving the tube nearer to the magnet. He found the effect extremely small until the tube reached a certain critical distance, at which the whole nature of the discharge suddenly changed. The difference of potential between the anode and kathode fell to below one-tenth of its original value, and the kathode rays were replaced by others which did not produce phosphorescence on the glass but manifested themselves by a glimmer along the lines of magnetic force. It is found that the magnetic force at the kathode is the chief factor which influences this sudden change, but the time that the discharge has been passing also influences it a little. A curve having for abscissæ the magnetic force at the kathode, and for ordinates the potential of the kathode at the moment of the change (the anode being connected to earth), is approximately a straight line, and for different gases the lines roughly agree. When the magnet acts on the kathode, particles of the metal of the kathode are projected violently against the glass and form a mirror on the tube. The pressure of the gas simultaneously falls, the gas condensing on the glass; and the amount of gas which thus disappears, other things being equal, is proportional to the current in the primary of the coil causing the discharge.

J. B. H.

512. *Hertz Resonators.* **A. Turpain.** (Comptes Rendus, 126. pp. 418–420, 1898.)—A circular resonator presenting a gap works as well as if the resonator were complete. The difference between the half-wave-length in the complete resonator and in the resonator with a gap, of the same radius, is $\lambda - \lambda_c = 2c$, where c is the length of the gap. A. D.

513. *Frequency of Hertzian Oscillations.* **L. Décombe.** (Comptes Rendus, 126. pp. 518–521, 1898.)—A direct method of measurement is described, by photographing the spark in the resonator-gap by means of a mirror rotating 500 times a second. Oscillations more frequent than 5,000,000 per second have been successfully photographed on gelatino-bromide plates. For very rapid oscillations the angular velocity of the mirror must be great; and the spark is put in the focal plane of a collimating lens of considerable focal length, so that the rays emerge parallel from this lens and are then received by the rotating mirror, which is concave and of short focus. With this arrangement, by rendering the focal length of the mirror short enough, any desired brilliancy may be given to the image on the photographic plate. The number of oscillations in a single spark-discharge depends on the capacity of the jar: as many as 40 have been counted. This tends to confirm both Poincaré's and Bjerknes' view, according to which only oscillations of a single frequency are emitted. A. D.

514. *Secondary Waves in Dielectrics.* **A. Righi.** (Memorie della R. Acc. dell' Istituto di Bologna, 6. p. 189, 1898.)—A resonator of natural wave-length 20 cm. is placed near a vibrator composed of two spheres 3·75 cm. in diameter and provided with a parabolic mirror. A solid glass sphere 8 cm. in diameter is placed with its centre 20 cm. or more from the middle of the resonator. When the sphere changes its place, it is found by experiment that the periodic electric force which it produces at R (the resonator) is a maximum or a minimum under the same circumstances as those given by calculation, supposing it placed in a constant field. Analogous results are obtained with a solid cylinder or a prism. By using two spheres or two cylinders, interference of the secondary waves may be observed.

If between an oscillator O and a resonator R, which are crossed, is introduced a dielectric D, the shape of which is not one of revolution about OR, the sparking of the resonator may reappear; there are four positions of D for which the sparking is a maximum, and four for which it is null. This effect persists even if the plate D is covered by a metallic screen with a circular opening between D and R. G. B. M.

515. *Electricity and Dermatology.* **W. S. Hedley.** (Elect. Rev. N. Y. 32. p. 39, 1898.)—This is a short review of the application of electricity to the cure of various skin-diseases, and

suggestions as to the possible application of powerful static charges to rid the surface of the body of micro-organisms and other conditions upon which cutaneous disease may depend.

W. G. R.

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516. *Death by Electricity.* **W. S. Hedley.** (Elect. Rev. 42. pp. 207–208, 1898.)—The author gives a summary of the views held on the actual causes of deaths by electricity. Among the conditions to be inquired into, the author emphasises the duration of contact. Small currents may kill when applied for 5 or 10 sec., and momentary, large currents, not fatal in single instances, likewise when repeated. The *post-mortem* generally shows apnœa, the left side of the heart being almost empty, the right side distended with dark, fluid blood; sometimes lesion of the nervous system, more frequently only slight hæmorrage in the fourth ventricle and in the meningeal coverings; mostly a burn on the spot where the current entered, not so frequently at the exit. Death seems to result from mechanical lesion (lightning), or from suspension of respiration or of the action of the heart or of nutritive exchanges. Death may begin at the heart, acting more upon the cardiac muscles (Tatum, L. Jones) than upon the nerves, or may be due to contraction of the arteries (Bleile) caused by affection of their nerves, or by constriction of the pulmonary arterioles consequent upon the deoxygenation of the blood. As regards the treatment, D'Arsonval's rule to proceed as in cases of drowning still holds good: artificial respiration should be commenced at once, and be long continued. Amyl nitrite may be beneficial, as it paralyses the walls of the small blood-vessels and counteracts constriction. H. B.

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517. *High-Tension Test for Dielectrics.* **C. E. Skinner.** (Elect. World, 31. pp. 300–302, 1898.)—A testing-set for voltages from 1200 to 100,000 is described, and the switching and regulating arrangements are illustrated. The current is supplied from a 30-kw. transformer that has its secondary divided into four equal sections. The primary is provided with resistance-loops brought out to a regulating dial; by this means, the current may be varied in steps of 1 per cent. of the maximum. A second transformer, with secondary wound to one-tenth of the first, is used for lower voltages. Both transformers are operated from the same regulator and primary switching-apparatus; the change is effected by a throw-over switch. The current goes to line through two plug-switches of the blow-out type; the circuit is made or broken through a mercury switch. With the exception of the final two terminals, the whole of the high-tension circuit is immersed in oil. The measuring instruments are direct-reading; they are of the Thomson inclined-coil type, with one terminal connected to the containing case to diminish static effects. The ammeter is used with an auto-transformer, so as to be capable of giving

a full-scale reading from one-sixteenth to sixteen times its normal range. This apparatus is well adapted to the investigation of high-tension discharges. A curve is given, showing the striking-distance between needle-points in air, from 0 to 200,000 volts, at 16,000 alternations. R. A.

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518. *Insulation Resistance (measured by Voltmeter).* **S. A. Russell.** (Elect. Rev. 42. pp. 251–254, 1898.)—The author describes the measurement by a voltmeter of the insulation resistance of a two-wire and three-wire system of mains. In the case of a two-wire system, the insulation of each main separately is deduced from three voltmeter-readings—one between the mains and one from each main to earth. In the case of a three-wire system, only the combined insulation resistance of the three mains to earth can be measured, though formulæ are given for finding a minimum value of the insulation of each main. By taking a double set of readings, however, varying the ratios between the voltages on the two sides, the three insulation resistances may be separately determined, though by somewhat complex formulæ. To obtain good results, the voltmeter-resistance should be comparable with that of the insulation; but the author recommends an electrostatic or high-resistance voltmeter, provided with two or three shunts. G. H. Ba.

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519. *Measurement of Low-Resistance Standards.* **W. M. Stine.** (Elect. World, 31. pp. 272–273, 1898.)—The author describes a modification of the Carey-Foster bridge for the accurate measurement of very low resistances, for use as standards. If P and Q be the reversible resistances of the bridge, P is a standard ohm; Q is made exactly equal to P by shunting Q with a high resistance, or by adding resistance in series with Q, as may be necessary. The low-resistance standard R is substituted for the slide-wire of the bridge, and the galvanometer-lead connected with one of its terminals (that nearest to Q); the resistance R is short-circuited with a heavy copper bar, and balance obtained under these conditions by adjusting the resistance of the connections. The short-circuiting bar is removed, and P is shunted with a high resistance S, so as to again obtain balance. The resistance of the standard R is then given by the formula

$$R = P - \frac{P \times S}{P + S}.$$

For a high degree of accuracy the galvanometer must be very sensitive and of low resistance, the connections heavy, and the apparatus protected from thermal effects by means of a cover. The author refers to a similar arrangement proposed by E. Willyoung (see Science Abstracts, No. 149, Feb. 1898.) A. H. A.

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520. *Kelvin Electrometer as Wattmeter and Voltmeter.* **E. Wilson.** (Elect. Rev. 42. pp. 308–309, 1898.)—The first section of the paper deals with the experimental verification of Maxwell's formula. In the Phil. Mag. for April 1885, Dr. J. Hopkinson had shown that the sensibility of the older type of electrometer increased with the charge on the needle up to a certain point, and beyond that diminished. This peculiarity was ascribed by Ayrton and Perry to the action of that portion of the guard-tube in the immediate neighbourhood of the needle. In the experiments described by the author two electrometers, numbered 71 and 184, were used. No. 184 was of more recent construction, with the portion of the guard-tube immediately surrounding the needle omitted. The author found that with a constant pressure between the quadrants of this latter type of instrument the deflection steadily increased up to the point of disruptive discharge, thus proving the correctness of Ayrton and Perry's hypothesis. Experiment also showed that Maxwell's formula held good, the greatest divergences observed amounting to 1·5 per cent.; these were within the limits of experimental error. Electrometer No. 184 was next connected up as a wattmeter, the case and needle being connected between the two points where the power was to be measured, and the quadrants being joined across a non-inductive resistance included in the main circuit. By taking curves of instantaneous pressure and current the mean value of the product of these two quantities could be determined, and so the relation connecting the electrometer deflection with the power obtained. A. H.

521. *McWhirter's Shielded Measuring Instruments.* (Elect. Engin. 21. pp. 330–331, 1898.)—These instruments are of the electromagnetic type, their novel feature being a shield to prevent disturbance from stray fields. The shield is a case of iron $\frac{1}{4}$ in. thick covering the coil and forming part of its magnetic circuit. Tests by Jamieson show that the shielding is excellent, the temperature error only $\frac{1}{4}$ per cent., and the error due to residual magnetism no greater than in the ordinary type. G. H. Ba.

522. *Interrupter for Induction-coils.* **V. Crémieu.** (Comptes Rendus, 126. pp. 523–526, 1898.)—A construction is described in which "make" and "break" are equalised by commutating so as to replace each by the sum of a make and a break, this being followed by a similar make and break in the opposite direction, and so on alternatingly. The equalisation is very effective; but the E.M.F. required is double that needed by a Foucault interrupter. The apparatus is reversible, so that an alternating current supplied to one coil produces a redressed fluctuating current in the other, with equidistant instants at which the current-strength is zero. Advantage is taken of this last circumstance, by an ingenious mechanism, to prevent sparking. A. D.

523. *Phasemeter.* **J. Tuma.** (Wien. Akad. Sitzber. 106. pp. 521–525, 1897.)—For a description of the author's earlier instrument see Abstract No. 290. The present paper contains an account of an improved form of the instrument. It consists essentially of two pairs of mutually perpendicular coils, one of which is fixed, the other movable. The fixed pair of coils is wound on slit spherical brass bobbins, the field due to each coil being thereby rendered very uniform. The movable system consists of two smaller mutually perpendicular cylindrical coils wound on paper frames and placed inside the fixed coils; the system is suspended by a silk fibre, and a pointer attached to the spindle supporting the movable coils indicates their position on a horizontal scale. Each of the two alternating currents, the phase-difference between which it is desired to determine, is made on entering the instrument to divide into two equal parts having a phase-difference of very nearly 90°. This is accomplished by connecting one of each pair of coils in series with a non-inductive resistance, and the other with a high inductance. Thus each alternating current is made to produce a rotating field. The connections are such that the two fields rotate in the same direction. Now the angle between the fields is the required angle of phase-difference. It is obvious that the movable system of coils will take up a position corresponding to coincidence of the two rotating fields. The angle between the fixed and movable systems of coils is then the angle of phase-difference. A. H.

524. *Graphical Methods in Alternate-Current Problems.* **C. E. Guye.** (Écl. Électr. 14. pp. 321–325, 1898.)—This is the first instalment of a paper on the above subject. After a brief historical introduction the author considers the fundamental assumptions which underlie the graphical method, and which frequently limit its range of application. These assumptions are :—(1) The variable quantities dealt with are simple sine functions of the time (if this condition is not fulfilled in practice, an *equivalent* sine function may be considered). (2) The *steady* state only is considered—no account being taken of abnormal initial phenomena such as occur when an alternating E.M.F. is suddenly introduced into an inductive circuit. (3) Where capacities are considered they are always supposed to be *constant* and *localised*; the complex phenomena arising in cases of distributed capacity not being dealt with. (4) The method is applicable to relatively *slow* alternations only, for which the resistance may be supposed constant. (5) Self and mutual inductances are supposed constant. The author then considers the representation of a simple periodic function by means of an alternating vector, and points out the desirability of uniformity in notation. A. H.

525. *Electric Osmosis.* **G. G. de Villemontée.** (Écl. Électr. 13. pp. 49–59, 106–111, 168–176, 208–217, 313–321, 395–403, and 497–507, 1897.)—The author gives a detailed

historical and critical account of electric osmosis and migration. The papers touch on the work of Becquerel, Daniell, and Miller, Pouillet, Hittorf, Almeida, Napier, G. Wiedemann, Quincke, Tereschin, Helmholtz, Lamb, and others. W. R. C.

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526. *Acoustic Properties of the Arc Light.* **H. T. Simon.** (Annal. Phys. Chem. 64. 2. pp. 233–239, 1898.)—The flame of an arc-lamp is very sensitive to slight variations of the current, such as those produced by induction from a neighbouring intermittent current. When the neighbouring circuit contains a microphone, the arc may be made to reproduce various sounds and noises communicated to the latter. It reproduces them with great fidelity. Conversely, a sound impinging upon the arc produces in it changes of density, which give rise to changes of resistance and modifications of the current, which may in turn excite a telephone. The arc thus plays the part of a telephone receiver and transmitter. E. E. F.

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527. *Magnetic Properties of almost Pure Iron.* **E. Wilson.** (Elect. Rev. 42. pp. 313–314, 1898.)—The iron studied contained traces of carbon and silicon, no phosphorus, 0·013 p. c. of sulphur, and 0·1 p. c. of manganese. Some of the results obtained with an *annealed* ring, having an internal diameter of 3·2 cm., an external diameter of 4·5 cm., and a depth of 2·6 cm., are given in the following table:—

Limits of H.	Limits of B.	$\frac{1}{4\pi}\int H dB$.	μ.	Coercive force in C.G.S. units.
0·783	1,965	262	2,510	0·50
1·14	4,840	......	4,245	
1·17	5,150	1080	4,400	0·73
1·42	7,500	......	5,280	
1·66	9,100	2490	5,480	0·90
2·23	11,460	......	5,140	
2·68	12,500	......	4,660	
4·74	14,270	......	3,010	
9·24	15,270	......	1,650	1·13

The author points out that an induction-density of 15,270 for $H=9·24$ is higher than he remembers having seen. Very noteworthy is the apparent *magnetic instability* of the iron under certain conditions. It is well shown by the following experiment. The magnetic force was changed from its maximum value through zero to the value of the coercive force, and the secondary circuit closed at known intervals of time *after* such change. The results are given in the table below.

Time in seconds	0.	1.	2.	3.	4.	5.	6.	10.
Change in B, 10 cells exciting through extra resistance	13,600	4,030	1,990	927	576	285	175	42
Change in B, 56 cells exciting through extra resistance	13,800	3,690	1,680	944	529	256	...	40

The object in using two different batteries is to prove that the time-constant of the circuit has nothing to do with the phenomenon. The figures show that 30 per cent. of the induction comes out after the first second has elapsed. With a total reversal from one maximum to the other no such effect was observed, the change taking place immediately. The author makes some calculations which show that the above results may be partly due to induced currents in the iron, but that they are principally due to a genuine magnetic instability. A. Gs.

528. *Physical and Chemical Modifications by Magnetism.* **D. Hurmuzescu.** (Écl. Électr. 13. pp. 357–362, 1897, and 14. pp. 279–284, 1898.)—The author has examined the variations, due to magnetism, of various quantities. In order to see if magnetism causes a change in volume, a solution of ferrous sulphate was made use of in a dilatometer. A contraction always takes place, which fact is not in harmony with Poisson's theory of magnetism. The specific resistance of iron increases when placed in a magnetic field, the value of $\frac{\Delta R}{R}$ being of the order 0·002. Copper is unaffected, and only a negative result was obtained with a solution of ferrous sulphate. Experiments are also described showing how chemical action is influenced by the lines of force in a magnetised iron plate, and how electrolytic deposits are affected (see Abstract No. 531). W. R. C.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

529. *Explosive Properties of Acetylene.* **Berthelot** and **Vieille.** (Annal. Chim. Phys. 13. pp. 5–29, 1898).—The memoir is in three sections :—

I. In the first section solutions of acetylene and their explosive properties are considered. It has been recently found that dissolving in acetone diminishes the danger of the use of acetylene in lighting. Tables of the tensions of the solution at various temperatures are given; they conform generally to Regnault's law for saturated vapours. As to the explosibility of the preparation, an iron bottle enclosing 320 c.c. of the solution of 41·25 per cent. strength was furnished with a submerged tube containing 1·5 grm. of fulminate; the detonation of the latter did not affect the acetylene. On the other hand, a solution of 64 per cent. at a pressure of 20 kilos at 13° C. undergoes explosion by simple inflammation. Steel tubes partially filled were fitted with a platinum wire immersed partly in the liquid and partly in the vapour; on raising the wire to incandescence the vapour always exploded, the liquid sometimes, but the pressures generated were only about one tenth of those which would have been caused by the gas alone. When, however, the liquid is saturated at pressures above 10 kilos per sq. cm., the result approximates to that with pure liquid acetylene, the acetone being completely decomposed at the same time, yielding H, CO, CO_2 and a compact mass of carbon. Experiments on a larger scale proved that the vessels commercially used for acetylene (tested at 250 atmospheres) could support without rupture an explosion of the gaseous atmosphere surmounting a solution in acetone, saturated under 6 to 8 kilos per sq. cm. at 10° to 15° C. At higher pressures no industrial recipient could withstand the explosion, a result which might occur accidentally through a rise of temperature. For example, a solution saturated at 14° C. under 6·74 kilos, would, if the temperature rose to 35°·7 C., which might easily occur by the heat of the sun or of a fireplace, exert a pressure of 10·55 kilos. As to the advantage of the solution, while a litre vessel of gaseous acetylene containing 2·5 grms. of the gas, corresponding to a pressure of 2 atm. at 0°, would be liable to explosion, a solution in acetone containing 100 to 120 grms. of acetylene would not explode at 15° if the pressure did not exceed 10 atm.

II. In the second section the authors deal with the decomposition of the solvent (acetone) in its physical relations. They point out that the complete dissociation of acetone requires a greater number of calories than can be furnished by the amount of the endothermic acetylene present in the ordinary solutions, which is the reason why the latter are not explosive when kept within the limits mentioned in the first section.

III. In the third section the authors further examine the conditions of explosibility when acetylene in large and in small steel

vessels is subjected to an incandescent wire, or to a fulminate detonator under known initial pressures. The results in the case of flasks show that although it is impossible to fix a definite critical pressure below which the propagation of explosion cannot occur, yet that below an excess pressure of 520 mm. of mercury for an incandescent point, or 170 mm. for a detonator, there is no probable danger. The capacity of the recipient does not seem to make any appreciable difference. It is singular that in steel tubes, although there was some liberation of carbon, no propagation of explosion occurred. S. G. R.

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530. *Ionisation in Mixed Salt Solutions.* **A. Fock.** (Zeitschr. Phys. Chem. 25. pp. 74–78, 1898.)—If c and x are the concentrations in a liquid and solid phase in equilibrium, and γ and g the ionisations, then must $\dfrac{c(1-\gamma)}{x(1-g)}$=constant and $c\gamma/xg$=constant. Also, by the law of mass action $c(1-\gamma)/x^2g^2$=constant, and $c^2\gamma^2/x(1-g)$=constant, which also follows from the ionisation-isotherms in the two phases $c(1-\gamma)=k$, $c^2\gamma^2$ and $x(1-g)=k_2x^2g^2$. If the ionisation in the solid phase is set = 0, we have $c(1-\gamma)/x$=constant and $c^2\gamma^2/x$=constant. In solutions of mixed salts of similar type the ionisation of each salt is generally supposed to be alike and unaltered by mixture, and therefore $=\gamma$ ionisation of the mixture, whence the last two equations should hold. This is not the case, but their sum remains constant $(c(1-\gamma)/x+c^2\gamma^2/x)$. The hypothesis of the constancy of γ is absurd, since we have then c/x and c^2/x or $c/\sqrt{x}$ both constant, which is impossible. Hence we must assume that γ varies, causing one expression to increase while the other decreases. The author assumes values of γ which make $c(1-\gamma)/x$=constant for mixed solutions of KCl and NH_4Cl, and finds the value of $c\gamma/\sqrt{x}$ remains practically constant. The dissociation in a mixture of equal molecules KCl and NH_4Cl being taken as that calculated for the mixture (5·5 normal) at 0·19, he finds the dissociation of NH_4Cl rise to 0·37, when the concentration c is lowered to 0·4, and the percentage NH_4Cl in the mixed crystals (from 10 %) to 1·2 %. B. B. T.

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531. *Electrolysis of Magnetic Salts.* (Elect. Rev. 42. pp. 322–323, 1898.)—This is an account of some experiments by Hurmuzescu on the behaviour of iron in electrolytic cells placed in strong magnetic fields. Two principal observations are made: one, that the rate of deposition and dissolution of iron electrodes is greatly affected by the magnetisation of the iron; the other, that electrolytes containing magnetic salts, placed in a magnetic field, show vortical movements, or eddies, when a current of electricity is passed through them. In one of these experiments an electrolytic cell, containing a ferrous electrolyte, is divided in the

middle by the two iron poles of a powerful magnet. The opposed edges are sharp and near to one another so as to obtain great concentration in the field-strength. When a current flows it is found that the deposition of iron is greatest on the highly magnetised edges. In a second experiment, between the two magnetised edges a small plate of iron is placed. Eddies then occur in the solution on each side when a current is passed. Some remarks on the regular way in which an iron-wire anode or iron-plate anode is eaten away, lead to the practical application of electrolysis in sharpening needles and knives. When a bundle of parallel wires is treated they become hexagonal in section, and do not remain circular. S. S.

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532. *Equilibrium in Solutions of two Salts with one Ion in common.* **C. Hoitsema.** (Zeitschr. Phys. Chem. 24. pp. 577–607, 1897.)—The author extends the theoretical conclusions of Nernst and Noyes to include the change in ionisation of the added salt, and obtains the following four equations:

$$xy=\mathrm{A}^2d_1^{\,2},$$
$$(a-z)/zy=k_2=a(1-d_2)/a^2d_2^{\,2},$$
$$x+z=y,$$
$$x+\mathrm{A}(1-d_1)=\text{Total solubility of salt XY};$$

where A is max. solubility of XY (sat. sol.), a is quantity of salt ZY added, d_1 and d_2 are the ionisations of these salts in the concentrations given, x, y, and z the concentrations of the ions. The latter three unknowns can be determined from three equations, and must satisfy the fourth. Excepting the case where addition of ZY does not increase y, the solubility of XY must always diminish, but eventually approaches a minimum. When the saturation point for ZY is reached the solution has a constant composition: this is the point where the same composition is attained by adding XY to a saturated solution of ZY, and may occur anywhere on the curve. Here we have the equations

$$xy=\mathrm{A}^2d_1^{\,2},\qquad zy=a^2d_2^{\,2},\qquad x+z=y.$$

Where a double salt XZY_2 is formed, dissociating only into XY and ZY (mixed crystals excluded), we have

$$xy=\mathrm{A}^2d_1^{\,2},$$
$$p/zy=k_2,$$
$$x+z=y,$$
$$q+p+z=a,$$
$$x+\mathrm{A}(1-d_1)+q=\text{Total solubility of XY};$$

where p and q are the concentrations of the undissociated ZY and XZY_2 salts. A sixth equation $q/p\mathrm{A}(1-d_1)=k_3$ must be satisfied, by solution of the other five. Here the solubility of XY is first diminished and then increased; interrupted at any point as before, by the saturation of the solution with ZY or XZY_2.

In the first case, the composition becomes constant; in the second, the composition remains constant while the solid XY is converted into solid XZY_2; when the former is exhausted, the amount of dissolved XY falls on addition of ZY until the solution is saturated with the latter. The conditions in the latter part of the curve are

$$r/xy=k_1, \qquad p/zy=k_2,$$
$$pr=\text{constant}=q\ \text{max.}/k_3, \qquad x+z=y,$$
$$p+z+q\ \text{max.}=a, \qquad x+r+q\ \text{max.}=\text{Total solubility of XY},$$

where a is the amount of ZY added.

[In original "konst." is written manifestly by a slip in the last two equations; read "bestimmbar."—B. B. T.]

Where a complex salt $X(ZY_2)$ is formed, dissociating only into X and ZY_2, we have

$$xy=A^2d_1^2, \qquad x=y+w,$$
$$q+w=a, \qquad x+A(1-d_1)+q=\text{Total solubility of XY};$$

where w is the concentration of the ZY_2 ions. The fifth equation $q/xw=k_4$ must also be satisfied. Here addition of ZY increases the solubility XY until saturation with $X(ZY_2)$ causes the composition to remain constant until the solid XY is exhausted. The concentration of XY then falls according to the equations

$$r/xy=A(1-d_1)/A^2d_1^2, \qquad q\ \text{max.}/xw=k_4,$$
$$x=y+w, \qquad a=q\ \text{max.}+w,$$
$$r+x+q\ \text{max.}=\text{Total solubility of X}.$$

When all XY is removed from solution the concentration of X still falls according to the changed conditions

$$q\ \text{max.}/xw=k_4, \qquad s/zw=k_5,$$
$$x+z=w, \qquad a=q\ \text{max.}+w+s+z,$$
$$x+q\ \text{max.}=\text{Total solubility of X};$$

where s is the concentration of the $Z(ZY_2)$ salt which appears in solution simultaneously with the vanishing of the Y ions (*i. e.*, of XY). In this stage we have only $X(ZY_2)$, $Z(ZY_2)$, and the three ions X, Z, and ZY_2. The composition becomes constant when $Z(ZY_2)$ separates in the solid state.

The reverse procedure leads to the curious result that the smallest addition of XY to a solution of ZY must convert the whole of the latter into $Z(ZY_2)$, by formation of $X(ZY_2)$ and double decomposition of the latter with excess of ZY. A sudden change in the solubility of ZY should be observed; if this is not the case we must conclude that ZY does not exist, $Z(ZY_2)$ being the original salt. From this point the solubility of $Z(ZY_2)$ increases according to the equations

$$s\ \text{max.}/zw=k_5, \qquad q/xw=k_4,$$
$$x+z=w, \qquad a=q+w+s\ \text{max.}+z,$$
$$x+q=\text{Total solubility of Z}.$$

In the case of mixed crystals, the author rejects Nernst's conclusions, inasmuch as the partition-coefficients of ions and molecules, with the equilibrium constants of ions and molecules in each phase, produce more conditions than can be simultaneously fulfilled, whether or no we assume an excess of positive ions in one phase and negative in the other.

Applying the same principles as above, the author concludes that the curves of solubility will exhibit similar forms to the foregoing, with sharp angles and points of constant composition where double salts separate out, or where the mixed crystals are converted into double salts, but otherwise with a smooth continuous course from axis to axis with or without maxima and minima. B. B. T.

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533. *Chemical Action of the Silent Discharge.* **Berthelot.** (Comptes Rendus, 126. pp. 561–575 & pp. 609–630, 1898.)—These lengthy papers, constituting a continuation of the researches of about forty years, already partially published in the 'Essai de Mécanique Chimique,' vol. ii. pp. 362–400, scarcely admit of abstraction within reasonable limits, and therefore only a general outline can be attempted. Among their results have been the discovery of the total synthesis of acetylene, of hydrocyanic acid, of persulphuric acid and its congeners, and of the continuous fixation of free nitrogen by plants under the influence of atmospheric electricity. Special attention has been given to the *limit of transformation* under defined conditions of time and intensity.

The apparatus generally consisted of a Ruhmkorff's coil and Leyden jar with a Marcel-Deprez break, giving several hundred alternate discharges per second, worked by five accumulators for a period of 24 hours, the sparks of the coil and jar being 12 to 15 mm. long. Examinations were made after 24 hours, and also at intermediate stages.

The substances occupied the annular space between two glass tubes one mm. apart; discs and metallic leaves were also employed. The liquids were weighed in small bulbs, which were then broken in the upper part of the annular space, the tension of the vapour being observed. In the case of liquids with little or no vapour-tension, such as fatty oils, their collection at the bottom of the tubes, out of reach of the current, precluded exact results; the same interference of purely physical conditions occurred between gases and solids. With solutions, there was the difficulty of imperfect contact between liquid and gas, besides the secondary action on the solvents.

The changes almost invariably pass through a succession of phases, under the lateral influence of the compounds formed, till a final equilibrium is established. As examples, organic substances deficient in oxygen produce at first a little acetylene, which subsequently disappears by condensation; methane and nitrogen give at first ammonia, to be later destroyed; carbon monoxide and carbon dioxide yield highly oxygenated compounds, afterwards

decomposed. The changes of volume are often very great—*e. g.* aldehyde with 14 c.c. of nitrogen gave in a few hours 64 c.c. of gas containing 11·5 c.c. methane, 7·3 c.c. hydrogen, 15·2 c.c. carbon monoxide, 11·5 c.c. carbon dioxide, 5·1 c.c. aldehyde-vapour, and 13·4 c.c. nitrogen. After 24 hours, 8·6 c.c. of gas, of which 7·3 c.c. was hydrogen and 1·3 c.c. nitrogen. In other cases, such as propylene, liquid polymers are first produced, and hydrogen is disengaged afterwards. The rapidity and even the nature of the reactions being functions of the intensity of discharge, it is essential to avoid internal brushes or sparks.

The final products are "solid or resinous" bodies of feeble conductivity with condensed and stable molecules, hydrogen, if in large quantity, remaining partially free, as in many similar inorganic actions. Compounds rich in oxygen furnish at first carbon monoxide, carbon dioxide, and water, with subsequent side-changes. Azotised bodies may first develop compounds containing more nitrogen, which may afterwards suffer decomposition with production of the free gas—the first fixation being in the form of amide or amine, and never in that of a nitric, nitrous, cyanogen or hydrazine derivative.

In every instance the initial action is a decomposition into hydrogen and simple binary compounds, with subsequent condensation into more complex molecules. The author draws a parallel between this and nutrition.

Details follow of experiments with gaseous mixtures under 24 hours of silent discharge. CH_4 and C_2H_6 gave about an equal volume of hydrogen; C_2H_4 at first formed a liquid, then about $\frac{1}{4}$ vol. of hydrogen: the condensation-product in each case being a hydrocarbon, $C_{10}H_{18}$, allied to the terpenes. With nitrogen they gave a "tetramine," $C_8H_{12}N_4$, solid, alkaline, and probably a polymer of acetylenamine. Acetylene condensed very rapidly to liquids, then to explosive solids oxidising very quickly in air. With nitrogen it gave $C_{18}H_{18}N_2$ or $C_{16}H_{16}N_2$, like the benzene-product. Propylene, trimethylene, and allylene behaved somewhat similarly. The synthetic azotised products constitute a new group of great interest.

Carbonic oxide, as Brodie and the author have shown, is broken up according to the equation

$$5CO = C_4O_3 + CO_2.$$

The suboxide C_4O_3 is a brown solid, soluble in water and of acid reaction. No combination between CO and N was occasioned in 12 hours.

Carbonic oxide with excess of hydrogen ($100\,CO + 244\,H_2$).—In 24 hours all the CO and about the same volume of H had disappeared, without production of CO_2 or C_2H_2; the condensed product consisted of a mixture of polymers of methyl aldehyde, CH_2O, some soluble, others insoluble in water. The former reduced nitrate of silver slightly, but not Fehling's solution, and blackened with burnt-sugar odour on heating.

Excess of CO ($100CO+50H_2$).—Results: 23 of residual CO, no H, no CO_2. Condensed product $C_3H_4O_3$, which may be either pyruvic acid, or $2CH_2O + CO$, or an oxidised carbohydrate, $C_6H_4O_4+O_2$, comparable to oxycellulose. It is similar to the product above, but has more reducing action.

Carbonic oxide, hydrogen and nitrogen.—Result in 24 hours: no hydrocarbon, CO_2, CO, nor NH_3. Condensed body corresponded to formamide, $HCO.NH_2$, or to $(CHN)_n, mH_2O+(n-m)H_2O$, a derivative of the first product $(CH_2O)_n$.—With a smaller proportion of CO the product had the composition $C_5H_4N_4O, 4H_2O$, which is that of sarcine. The smallness of the quantity precluded separation.

Carbon dioxide alone gives percarbonic acid, CO, and the suboxide described above. With hydrogen the CO_2 disappears, and there are found a few drops of an aqueous syrup, CH_4O_2 or $(CH_2O)_n+nH_2O$, smelling of acetic acid, but otherwise like the product with CO. With hydrogen and nitrogen in excess, no CO_2 or CO remain, while ammonium nitrite is formed, along with an unstable substance of the empirical formula $CHO.NH_2$. With less H and N, the result approximates to $CONH_2, H_2O$. Therefore, with excess of hydrogen, the general equations are:—

$$\left.\begin{matrix} n(CO+H_2) \\ n(CO_2+2H_2) \end{matrix}\right\} = C_nH_{2n}O_n - mH_2O\ ;$$

a synthesis analogous to some of those occurring in plants, and connected with their formation of the nucleus or residue CH_2O from CO_2 and H_2O by elimination of O. If the hydrogen is deficient, the products are more highly oxidised. The addition of nitrogen yields bodies rich in this element, of the general formula $(COH_3N)_n-mH_2O$, related to the polymers of hydrocyanic acid and to the uric or xanthine family—or, if the oxides are in excess, to that of the ureides. When water is formed at the same time, especially with CO_2, ammonium nitrite appears, which is a normal product of the fixation of N on the elements of water.

The succeeding portion of the memoir describes the action of the discharge on alcohols and ethereal derivatives in presence of N. As regards the alcohols, the first stage is marked by a liberation of hydrogen, which continues at a lessening rate to the end of the process. Afterwards N is absorbed in the ratio of one atom to two of H lost, resulting in condensed alkaline bodies resembling the amidines. The loss of H is one atom in the case of methylic, and two in that of ethylic and propylic alcohol, similar to the behaviour of CH_4 and C_2H_6. Allylic alcohol, like acetylene and allylene, loses no H, though it fixes N in the ratio of N_2 to 3 of C_3H_6O. Phenols, like their parent hydrocarbons, lose no H, but fix N in unequal proportions, the products being neutral. Ethers behave like their related alcohols. Except

methylic, the alcohols fix about twice as much nitrogen as their parent hydrocarbons. Isomeric alcohols behave in the same way; isomeric phenols do not. S. G. R.

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534. *Electrolytic Estimation of Cadmium.* **D. L. Wallace** and **E. F. Smith.** (Chem. News, 77. pp. 93–94, 1898.)—Smith's experiments of 1878 having been doubted by Heidenreich and others, the authors have repeated them with definite units. Solutions of cadmium acetate or sulphate, not too acid, were precipitated at 50° C. by a current of 0·02 to 0·08 ampere for 37 sq. cm. kathode-surface, voltage 2·5 to 3·5, in 4 to $4\frac{1}{2}$ hours, in a crystalline and firmly adherent form, with excellent quantitative results. Neumann has, moreover, succeeded in the process. Smith's method of separating copper from cadmium was also confirmed. In the presence of free HNO_3 (about 2 per cent.) copper is completely deposited, while all the cadmium remains in solution. S. G. R.

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535. *Taste of Acids.* **T. W. Richards.** (Chem. News, 77. pp. 91–93, 1898.)—The author is of opinion that the sourness of acids is probably to be referred to the hydrogen ion. The water used had been distilled in platinum from alkaline permanganate, and then redistilled, and was singularly tasteless. About 5 c.c. of the solutions, warmed to 40° C., was held on the tongue for a few seconds, "until a constant intensity of taste was secured." Beakers with 10 c.c. of water and 0·05, 0·10, 0·20, and 0·30 c.c. of decinormal HCl, and with unseen labels, were readily classified correctly by taste; 0·3, 0·4, 0·5, and 0·6 c.c. of the acid gave less accuracy, a mistake being made in the order of the last two. With H_2SO_4, HNO_3, and HBr, the sensitiveness was about the same, a strength of somewhat less than millinormal seeming the limit of detection. A liquid distinctly sour became tasteless on neutralisation; hence neither K nor Cl ions can possess so strong a taste as those of H. The order of decreasing sourness was found to be: mineral acids, tartaric, citric, acetic. The latter tasted as strong as HCl of $\frac{1}{3}$ its concentration, although Kohlrausch had found that at $\frac{1}{333}$ normal only about $\frac{1}{14}$ of the acid was dissociated (Wied. Ann. 26. p. 161, 1885). Small additions of KCl had no appreciable effect on the taste of very dilute HCl, whereas the sourness of acetic acid was noticeably diminished, and that of HCl almost destroyed, by small amounts of K or Na acetates, in accordance with the dissociation hypothesis and the mass law, "which tells us that in such a reaction as

$$CH_3COOH \rightleftarrows H + CH_3COO-$$

the addition of a large proportion of acetic ions from the almost wholly dissociated sodic acetate is capable of forcing the reaction backwards and destroying the hydrogen ions." This is analogous

to the effect of salts in modifying the catalytic action of acids on cane-sugar and esters. An application of these principles occurs in the preparation of soda-water, whose sourness is rendered soft to taste by the addition of sodium bicarbonate.

The author then applied the sense of taste to ascertaining the end-point of an acidimetric determination, adding a slight excess of acid, and then alkali till the sourness just disappeared. The figures given indicate that surprising delicacy may be attained with practice. The tastes produced by small electric currents, and also the effect of sugars in mitigating undue sourness, were examined with as yet unsatisfactory results. S. G. R.

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536. *Electrolysis of β-methylglycidic and β-methylglycerinic Acids.* **L. B. Pisarjewsky.** (Journ. Russ. Phys. Chem. Soc. 29. pp. 338–340, 1897; also Ècl. Élect. 14. pp. 443–444, 1898.)—On electrolysing the potassium salt of β-methylglycidic acid, oxidation takes place with formation of formic and acetic aldehydes and acids, and an unidentified substance which reduces Fehling's solution powerfully, and forms a gummy yellow barium salt: of these, formic aldehyde is the chief product. The gases evolved consist of 70–75 p. c. CO_2, 14–16 p. c. CO, 10–12 p. c. O_2, and 0·4–0·6 p. c. gas absorbed by H_2SO_4; the amount of CO and O_2 increases with the dilution. Potassium β-methylglycerinic acid gave the same products but in noticeably different proportions, less formic aldehyde, more acetic acid, and more CO (38 p. c.) and O_2 (19 p. c.). The latter may be due to the greater dilution employed. B. B. T.

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537. *Guttapercha.* **E. Obach.** (Elect. Engin. 21. pp. 20–22, 51–53, 115–117, & 146–147, 1898.)—The earliest recorded specimen of guttapercha seems to have been brought to Europe by the Tradescants about 1560 and deposited in their museum. In 1843 it was rediscovered by Drs. D'Almeida and Montgomerie, and submitted by the latter to the Society of Arts, who reported favourably on its utility. In 1847 the tree was first named and figured by Sir W. J. Hooker; during the same year, Dr. Ernst von Siemens introduced the material as an insulator, and designed a machine for covering wire.

The original source of guttapercha, and still the origin of the best material, is a lofty tree native to Singapore and other Malay countries, and is called Jaban Merah in Perak and Niato balam tembaga (or abang) in Sumatra. It is from 60 to 150 ft. high and from 2 to 5 ft. in diameter. The gum is derived from the milky juice or latex, which is contained chiefly in the inner parts of the bark, also in the pith and leaves, but not in the wood. An elaborate description of the leaves, flowers, etc., with illustrations and photographs, was given in the lecture, from which it appears that although the leaves may vary in size and shape, the general botanical

characters are very distinct. Sir W. Hooker's original name of *Isonandra gutta* has been superseded by that of *Dichopsis gutta* (Benth.) in England, or *Palaginium gutta* (Burck) on the Continent. The natural order is Sapotaceæ. The tree, which attains maturity in about 30 years, is very irregularly distributed in the islands, and is becoming scarcer.

Recent explorations in German New Guinea have discovered several species, *e.g.* Getah Susu, Maran, and Natu, closely allied to guttapercha, but the gums, according to the author, have no resemblance. Only one of them contains a small percentage of "caoutchouc-like substance or pseudo-gutta."

The destruction of the trees by the Malays having threatened the further supply, the French Government in 1881 sent an expedition to search for the trees and enquire into their possible cultivation. Seligman discovered a number of various kinds, including the true gutta, of which he forwarded young plants to Europe.

A second and English expedition was sent from Perak, in 1883. Leonard Wray collected plants and specimens from a number of caoutchouc and gutta-producing species, with the coagulated latex or "getah" from seven different trees, and obtained much information. He comments upon the wasteful manner in which the gum is collected by the natives, and suggests that the bark—which in the dry state contains over 11 % of guttapercha, and is now thrown away—should be utilised for extraction.

The physical properties of guttapercha are well known. The softening temperature varies, but never exceeds 66° C. By destructive distillation, *isoprene* C_5H_8, sp. gr. 0·682, B.P. 37° C., and *caoutchine* $C_{10}H_{16}$, sp. gr. 0·842, B.P. 171° C., and other hydrocarbons identical with those from caoutchouc, are obtained.

Tilden has succeeded in reconverting isoprene into caoutchouc by means of strong hydrochloric, or in the presence of acetic or formic acid, thereby suggesting a synthesis of the gums from the lower terpenes. Quite recently two Russian chemists have proved isoprene to be asymmetric methyldivinyl, $CH_2=C(CH_3)-CH=CH_2$.

Guttapercha is destroyed by strong nitric or sulphuric acid, but not by other acids nor by alkalies. Alcohol, ether, and many other solvents dissolve it partially, extracting mainly resinous bodies; in carbon disulphide, chloroform, and carbon tetrachloride it is completely soluble, leaving the impurities. S. G. R.

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538. *Ionisation in Aqueous Alcohol Solutions.* **E. Cohen.** (Zeitschr. Phys. Chem. 25. pp. 1–45, 1898.)—The conductivity at 18° C. of KI in absolute and aqueous alcohol in concentrations from $V=64$ (litres per gramme-mol. wt.) to 4096 is measured with great care, and $NaC_2H_3O_2$ in 50 % alcohol from $V=64$ to 1024, and measurements by others of KCl, NaCl, HCl, etc. are criticised and compared, with the following results:—

1. Replacement of alcohol by water in an alcoholic solution generally raises the conductivity; but with very weak solutions

(V=256, or 512 and over) the solution in absolute alcohol may have a higher conductivity than the aqueous solution (99 °/₀ to 80 °/₀).

2. In solutions in weak alcohol, the alcohol strength has the same influence on the conductivity for all concentrations, for all the various (strongly dissociated) salts investigated, and apparently for different temperatures. The conductivity of a dilute solution (lower limit of V about 64 for 40 °/₀ to 512 for 100 °/₀ alcohol) may be obtained from that of an aqueous solution of equal strength by multiplying by the [approximate] factors :—

10 °/₀	20 °/₀	30 °/₀	40 °/₀	50 °/₀
0·73	0·57	0·47	0·40	0·35

This enables the limit of conductivity at infinite dilution for alcohol solutions to be calculated from aqueous solutions. It should follow from this that the ionisation is the same in alcohol (up to 60 °/₀) as in water solutions at the same concentration; but the author prefers, on other grounds, to hold that the conductivity is no correct measure of the ionisation.

See also Walker & Hambly, J. Chem. Soc. 72. pp. 61–72, 1897.

B. B. T.

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539. *Avogadro's Law and the Liquid State of Aggregation.* **U. Dühring.** (Annal. Phys. Chem. 62. 1. pp. 204–205, 1897.)—A reclamation: J. Traube has stated that Avogadro's law for gases may be applied to liquids, if we consider only that part of their volume which is not occupied by the molecules themselves and their sphere of action. E. and U. Dühring have gone further, in 1886, in proving this extension of the law to hold both for liquids and solids. It is, however, necessary to consider equal heat pressures and not external pressures. For the pressure produced by the heat in the interior of a liquid is entirely different from the pressure observed on some boundary surface. The heat pressures of various liquids differ for equal temperatures and equal external pressures, as Dupré pointed out more than forty years ago. H. B.

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540. *Metallic Sulphide Electrodes.* **I. Bernfeld.** (Zeitschr. Phys. Chem. 25. pp. 46–73, 1898.)—The author investigates electrolysis with electrodes of the natural ores PbS, Fe_7S_8, $CuFeS_2$, Cu_3FeS_3, FeS_2, Sb_2S_3, MoS_2, and artificial FeS in solutions of HCl, HNO_3, H_2SO_4, NaOH, and Na_2SO_4. The following reactions are found to be general :—

1. Sulphide as anode. In acid solution, the metallic constituent is dissolved, the sulphur remains or is oxidised (by greater current-density) to sulphuric acid. In alkaline solution, the metal is turned into hydroxide, the sulphur is oxidised in various stages up to H_2SO_4.

2. Sulphide as kathode. H_2S is formed at the kathode and the metal remains; the ores usually crumble to pieces. In alkaline solution, the sulphur is dissolved as alkaline sulphide, the metal remains as sludge.

The author endeavoured to measure the resistance of galena without finding any fixed value ; the temperature coefficient is negative, but no electrolysis could be ascertained. Electrolysis of PbS in NaOH showed agreement with Faraday's law. In measuring the potential of PbS and AgS constant values could only be obtained by keeping the concentration of H_2S in the electrolyte constant; natural PbS is always some 0·02 volts lower than the artificial. The variations in E.M.F., with dilution of the Na_2S solution agreed with the univalence of the active ion, from which the author is led to the following scheme of electrolysis for a concentration cell of PbS in Na_2S (saturated with PbS) :—

$$\begin{array}{lr|l} & \mathrm{Pb}+2\mathrm{SH}'+ & \mathrm{HSH}+\mathrm{PbS} \\ \text{becomes} & \mathrm{PbS}+\mathrm{HSH} & +2\mathrm{SH}'+\mathrm{Pb}, \end{array}$$

the current flowing from concentrated solution to dilute, in the electrolyte, with formation of undissociated H_2S in the former and dissociated SH′ ions in the latter (Na′ ions are not represented). From this the formula

$$E=\frac{RT}{\epsilon}\log\frac{p'}{p}-\frac{RT}{2\epsilon}\log\frac{p'_1}{p_1}$$

for the E.M.F. is obtained, where p' and p are the concentrations of SH′ ions, p'_1 and p_1 of the H_2S molecules : this was proved for varying strength of NaHS, and [roughly] for varying strength of H_2S (by expelling gas from saturated solution by nitrogen). Ag_2S and Bi_2S_3 gave similar results. The solubilities of the sulphides calculated from these potentials (with the help of the supposed chain, Metal—normal metallic nitrate—normal NaHS—metallic sulphide) gave Ag_2S $3{\cdot}4\times10^{-22}$, PbS $2{\cdot}9\times10^{-5}$, Bi_2S_3 $2{\cdot}1\times10^{-26}$.

B. B. T.

541. *Calculation of Conductivity of Mixed Electrolytes.* **J. G. MacGregor** and **E. H. Archibald.** (Phil. Mag. 45. pp. 151–157, 1898.)—According to the dissociation theory, the specific conductivity of a complex solution, volume v of which contains N_1, N_2, N_3, ... gramme equivalents of electrolytes 1, 2, 3 . . . . respectively is given by the expression

$$\frac{1}{v}(\alpha_1 N_1\mu_{\infty 1}+\alpha_2 N_2\mu_{\infty 2}+\alpha_3 N_3\mu_{\infty 3}+\ldots\ldots),$$

in which α_1, α_2, α_3 . . . . are the coefficients of ionisation and $\mu_{\infty 1}$, $\mu_{\infty 2}$, $\mu_{\infty 3}$. . . . the specific conductivities per gramme equivalent at infinite dilution. The value of μ_∞ for an electrolyte in a complex solution may be taken to be the same as in a simple solution, provided the dilution is sufficient. If it be assumed (1) that any dissolved electrolyte, which is in dissociational equilibrium, may be regarded as being in this state, not only throughout the whole volume of the solution, but also throughout any finite part of it, and (2) that each electrolyte in a complex solution, with its undis-

sociated and dissociated parts, though disseminated throughout the whole volume, may be regarded as occupying a definite portion of the volume, then equations may be formed sufficient to determine $a_1, a_2, a_3 \ldots$ and $N_1, N_2, N_3 \ldots$ and thus the conductivity. The equations, however, are not very suitable for working with. The authors, therefore, in order to test the theory, made up solutions of potassium chloride, sodium chloride, potassium sulphate, and sodium sulphate of equal ionic concentrations. These were then mixed in equal volumes. Since no change takes place in the ionisation, the four values of a and of N are known, and the conductivity of the mixture may be calculated. The values so found support the theory. The differences between the observed and calculated values of the conductivity, in a series of sixteen different concentrations, range from 0·7 to 0·2 per cent. W. R. C.

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542. *Error in Estimating the Heat of Ionisation of Electrolytes.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 24. pp. 608–614, 1897.) —The degree of ionisation of the solvent (β) as well as of the dissolved substance (α) changes with the temperature. That is to say, in the constant of Ostwald or Rudolphi

$$K_1' = K_1(1+\beta)^{\nu_2-1} . f^{\nu_2-1} \Big/ (\overset{+}{\nu_2})^{\overset{+}{\nu_2}} (\overset{-}{\nu_2})^{\overset{-}{\nu_2}},$$

the term $(1+\beta)^{\nu_2-1}$ must also be taken into account.

Thus instead of

$$q_1 = RT^2 d \log K_1/d\tau,$$

the author obtains

$$q_1 = RT^2\{d \log K_1'/d\tau + (\nu_2 - 1) d \log A/d\tau\},$$

where A, the factor of association, $=2/1+\beta$.

This correction is important, as shown by comparing the values of $RT^2 d \log K_1'/d\tau$ already found (KCl -364 g. cal., KNO_3 -140 g. cal., etc.) with the value of $RT^2 d \log A/d\tau$ for water, which is reckoned by the author from Ramsay's measurements to -364 g. cal. at 35° C.

The above equation may be re-written for convenience

$$q_1 = \frac{\nu_2 - (\nu_2 - 1)\alpha}{1-\alpha} RT^2 \frac{d \log \alpha}{d\tau} + (\nu_2 - 1) RT^2 \frac{d \log A}{d\tau},$$

where $\frac{d \log \alpha}{d\tau}$ may be calculated from $\alpha = \frac{\mu_v}{\mu_\infty}$. Thus for KCl by 35°, q_1 is calculated to $-364-364=-728$ g. cal. as above.

If we assume with Rudolphi that $\nu_2 = 1\frac{1}{2}$ (instead of 2, Ostwald) we obtain $q_1 = -524$ g. cal., from which difference the author hopes to decide between the two hypotheses. B. B. T.

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543. *Electrolytic Preparations.* **K.** (Électricien, 15. pp. 59–61, 1898.)—Allusion is made to Lükow's researches. In preparing an insoluble salt, the electrolyte should consist of 80 % of a soluble

salt of the anode metal and 20 % of the salt which is to cause the precipitate. For oxides, the electrolyte should contain 95 % to 99·5 % of a salt whose anion forms a salt soluble with difficulty, and 5 % to 0·5 % of a salt whose anion forms an easily soluble salt with the anode metal. Details are given for the preparation of various bodies, such as peroxide of lead, chromates of lead, basic carbonate, and basic phosphate of copper. W. R. C.

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544. *Electrolytic Bleaching and Disinfecting Solutions.* **M. C. Beebe.** (Electrician, 40. pp. 421–423, 1898.)—The author carried out experiments upon the electrolytic decomposition of magnesium and sodium chlorides with a view to determine the power required in obtaining bleaching solutions and the effect of density and temperature. He arrives at the following conclusions: (1) The amount of available chlorine in solution is not proportional to the power expended. (2) It depends upon the temperature. (3) It also depends upon the amount of the products of decomposition already formed in the solution. (4) At fairly high temperatures (50° C.) there may be an actual decrease in the amount of available chlorine per ampere-hour. (5) The amount of available chlorine per ampere-hour depends largely upon the density of the electrolyte, dense solutions giving more than dilute ones. (6) The effect of current density upon the efficiency cannot be definitely stated. (7) If the temperature is kept below 15° C. it is possible to reach a concentration of 9·7 grammes of available chlorine per litre at an efficiency of 0·9 gr. per ampere-hour, using NaCl solution of 1·100 sp. gr. (8) A dilute solution disintegrates carbon anodes much more rapidly than one that is concentrated. (9) Frequent reversal of the current to lessen polarisation and resistance greatly reduces the efficiency. (10) Polarisation for a given temperature and density of electrolyte remains constant, regardless of current density.

A number of curves are given illustrating the results. W. R. C.

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545. *Electrolytic Manufacture of Parabolic Reflectors.* **S. Cowper-Coles.** (Journ. Inst. El. Eng. 27. pp. 99–115, 1898.)—This process consists of an electrolytic method for the production of metallic mirrors from a glass or highly polished surface. The process is being used for the manufacture of parabolic reflectors for search lights. On a highly polished surface is first of all deposited a coating of metallic silver, which is thrown down chemically and then polished so as to ensure the copper backing being adherent to the silver. The mould, after silvering, is placed in a suitable ring and frame, and then immersed in an electrolyte of copper sulphate, the mould being rotated in a horizontal position, the number of revolutions being about 15 per minute. The copper adheres firmly to the silver, and together they form the reflector, which is subsequently separated from the glass mould by placing the whole in cold or lukewarm water, and

then gradually raising the temperature of the water to 120° Fahr., when the metal reflector will leave the glass mould, due to the unequal expansion of the two. The surface obtained is an exact reproduction of the surface of the mould, and has the same brilliant polish. It requires no further treatment to answer all the purposes of a reflector, with the exception that it must be coated with a film of some suitable metal such as palladium, which is found to resist tarnishing to a wonderful degree. AUTHOR.

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546. *Electrolytic Treatment of Ores.* **C. E. Webber.** (Journ. Inst. El. Eng. 27. pp. 38–99, 1898.)—The author considers the treatment of ores containing the precious metals. After dealing with the subject historically, a description is given of the Pelatan-Clerici process which is being worked at Rossland (B. C.). W. R. C.

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547. *Manufacture of Electro-Chemical Products.* (Elect. Rev. 42. pp. 333-337, 1898.)—In this article a general outline is given of the processes carried on, and the plant in use at the works of the Electro-Chemical Co., of St. Helen's. In the manufacture of caustic soda, chloride of lime, and chlorate of potash, brine is supplied through mains to the decomposing-cells from an elevated tank, so that the cells can be filled by merely turning taps. The decomposing tanks are 20′ × 3′ × 1′ 3″ deep, and are divided into 16 cells. The anodes consist of irregular blocks of carbon embedded on a lead strip fixed in an earthenware box which is inverted in the cell but does not reach quite to the bottom, so as to permit the liquid to circulate freely inside. A simple wrought-iron grid forms the kathode. The hydrogen formed is allowed to escape into the atmosphere. The chlorine passes through a port-hole in the anode-box into a closed conduit running the whole length of the tank, and connected to an earthenware main which conducts it to the bleaching-chambers and to the chlorate of potash plant. The E.-C. Co. state that they have no difficulty in maintaining their bleaching-powder at market strength, since they are not liable to trouble from CO_2. The caustic soda is purified from salt by a preliminary evaporation process, in which the salt is precipitated and removed by means of a revolving frame which shovels out the salt from the bottom of the receiving-tank. The engines were made by Messrs. Yates & Thom, and are of the marine type, compound and condensing, working at 135 lbs. per square inch. In a test they gave 1 H.P. hour for 14 lbs. steam, the average indicated H.P. being 711·35. Lancashire boilers are employed. The engines drive the dynamos through rope-gearing. These dynamos each develop 1250 amperes at 180 volts at 400 rev., and are made with Sayer's windings. The switches are worked by a system of railway-levers, and were built under Mr. Slater Lewis' patents. The distribution is effected through a bare stranded cable, joints being avoided by untwisting a strand at places where a branch is to be taken. C. K. F.

GENERAL ELECTRICAL ENGINEERING.

548. *Storage-Battery Testing.* **R. Kennedy.** (Elect. Rev. 42. pp. 386-387, 1898.)—The author discusses the loss of capacity of storage-cells which is observed as the rate of discharge is increased, and points out the necessity of testing cells at high rates of discharge as well as at low rates for the purpose of comparison. Given two cells which have the same capacity when discharged in 7 hours, it by no means follows that they will have the same (reduced) capacity when discharged in 1 hour. This fact is especially important in the case of central-station cells, which may at times be discharged at very high rates. An instance is given showing a marked improvement in the capacity of a cell at high rates, effected by structural alterations. A. H. A.

549. *Samson Primary Battery.* (West. Electn. 22. pp. 133–134, 1898.)—This cell is of the Leclanché type. The special feature is the carbon, which is made in two parts. The lower part is a thin-walled, fluted, hollow cylinder, made very porous. The top part is made of a different kind of carbon and subjected to a very high pressure. After the two parts have been baked in a kiln, the top of the carbon is made red-hot and plunged into hot paraffin. The latter thus enters into the smallest pores, and creeping of salts is prevented. A combination of manganese and pea-carbon is placed inside the fluted portion and held in position by a prepared plug. The depolarising power is said to be much greater than usual in this form of cell. W. R. C.

550. *Lalande Primary Battery.* (Électricien, 14. pp. 401–403, 1897.)—An improved form of this cell is described. W. R. C.

551. *Sentinel Circuit-Breakers.* (Elect. Rev. 42. pp. 315–316, 1898.)—In this automatic circuit-breaker, the actual disruption of the circuit is accomplished by the breaking of a brittle metal bar, by means of a released spring hammer, which is included in the circuit, and which is provided with grooves to localise and insure the break. An illustration of the apparatus is given. It is said to be very reliable. W. G. R.

552. *New Type of Circuit-Breaker.* (Elect. World, 31. p. 229, 1898.)—A circuit-breaker is now constructed by the Ward Leonard Electric Company, Bronxville, N.Y., in such a fashion that each side of the circuit in the double-pole type is separately closed. The instant the current flows, the side of the switch not held by the operator will automatically fly open and open the circuit if an overload or circuit switch exists. If an overload occurs later, after the operator has left the switch, then both poles will open

simultaneously. In both cases the circuit is instantly interrupted, and all arcing occurs on carbon. The only adjustment is that of raising or lowering a vertically movable core of a solenoid magnet. The adjustment ranges from 25 per cent. under to 50 per cent. over the current which the circuit-breaker will carry continuously. The adjustment-readings cover a long range of travel of the core, and are all well defined and easily read. W. G. R.

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553. *Electric Heating and Cooking.* **W. P. Adams.** (Elect. Engin. 21. pp. 107–110, 1898.)—In this paper the author reviews the possibilities of heating and cooking by electricity, with especial regard to cost. The apparatus required to cook for 8 to 10 persons are an oven, taking 2500 watts for the first 15 minutes and 1200 afterwards; a breakfast cooker with two circuits, each 600 w.; two grillers and two frying-pans, each 500 w., and several hot-plates, or electric saucepans, taking about 1500 w. The maximum possible demand would be 7200 w., but this is never approached in practice; the maximum demand for lighting purposes in such a household would be about 2500 w. Private consumers supplied from central stations are the most likely to adopt electric cooking; but electrical energy for this purpose must be supplied at a moderate price. The author considers that 1*d.* per unit will soon be possible, having in view the improvement of the day load, while in many cases the charge is already reduced to 3*d.* or less, and the total cost is under 2*d.* per unit. An increase of load in the summer due to the use of electricity for cooking is almost certain, as is shown by the experience of the gas companies. In a certain household of five persons, where both gas and electric cooking-apparatus were installed, the consumption of gas per week was 1240 cb. ft., costing 3*s.* 9*d.* at 3*s.* per 1000 cb. ft., and of electrical energy 30 units, costing 5*s.* at 2*d.* per unit, when either was used exclusively. The average consumption of electricity is 1 unit per head per day in small installations, but may be reduced to one-half this value in large establishments. Heating water by electricity is expensive, and a separate hot-water stove is recommended for this purpose. Where isolated plants are in use, the extra cost of energy for cooking is very small, especially if the plant be of large size; water-power installations are exceptionally well adapted for the application both of electric cooking and heating. Electrical heating is very different from cooking, as it increases the load in winter, but is not called for in summer. A fair allowance for the energy consumed is 500 watts per 1000 cb. ft. of space in very cold weather. The expense is heavy, unless energy is supplied at a very low charge; but the convenience and sanitary qualities of electric radiators somewhat counterbalance this objection. Electrical heating is recommended for use on board ship. A large number of data of generating costs, etc. are included in the paper. A. H. A.

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554. *Electric Floor-Scrubber.* (Elect. Rev. N.Y. 32. pp. 83–84, 1898.)—This device, which is patented by H. F. Ackerman, of Cleveland, Ohio, consists of a frame mounted on rubber-tired wheels and carrying an electric motor. This motor drives three rectangular scrubbing-brushes mounted at the ends of vertical shafts and pressed against the floor by springs, these shafts being connected to the motor through bevel- and chain-gearing, so as to revolve at about 400 rev. per minute. A rheostat is mounted on the handle of the machine, the current being supplied to the motor by a flexible cord which may be attached to any convenient lamp-socket; the slack cord is taken up by a spring-tensioned reel mounted on an upright on the frame. The machine weighs about 300 lbs., and is about 30 in. square. By replacing the scrubbing-brushes by sandpaper blocks or blocks of stone, the machine may be utilised to dress down wood floors, the decks of vessels, or mosaic tiling. C. K. F.

555. *Mechanical Applications of Electricity.* **G. Richard.** (Écl. Électr. 14. pp. 410–417, 1898.)—This is chiefly an account of the applications of electricity in naval matters. The General Electric Company have recently proposed a system of signalling from one ship to another by means of semaphores worked by solenoids with movable iron cores. By this arrangement it is easy to produce a different signal for each letter of the alphabet and to work the arrangement with rapidity. Messrs. Siemens & Co. have brought out a buoy carrying glow-lamps. G. Griffith has invented an electric sounder such that an electric bell is rung as soon as ground is touched. W. G. R.

556. *The Stresses and Deflection of Braced Girders.* **W. H. Macaulay.** (Phil. Mag. 45. pp. 42–65, 1898.)—In the case of a pinned frame which has no more members than are needed to define its shape, the stresses under a given system of loading are to be found by a force-diagram, or by resolution of forces. If, however, there are additional or redundant members, forming bracing which can be removed without making the frame loose, it is necessary to take into account the elasticity and strength of the various parts of the structure. The general problem of determining the stresses in a frame with redundant members, and its deformation (assumed to be small) in any direction, under the action of given forces applied at joints, was first solved by Clerk Maxwell. His solution was published in the 'Philosophical Magazine' in 1864, and is reprinted in his Collected Papers. The only objection to it is the formidable length of the calculations, which are apt to be involved in the application of it to any but very simple cases.

The object of the investigation in the present paper is to obtain by Maxwell's method some general results for certain types of girders, and to compare them with the results given by other less

exact methods of procedure. Maxwell's equations are solved for a parallel girder with N panels and N redundant members, and it is shown that, in the cases considered, the stresses and deflection can be presented explicitly in a manageable form. The comparison with the results given by the ordinary Euler-Bernoulli method for determining the deflection of a uniform beam is discussed; also the applicability of the method of obtaining stresses by regarding the girder as compounded of two simpler ones. The results for another type of girder are given, and finally the corrections for stiffness of joints are discussed. AUTHOR.

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557. *Marvin's Electric Percussion Drill.* **F. H. Loring.** (Elect. Rev. N.Y. 32. pp. 156–157, 1898.)—The drill-chuck is forged in one piece with a soft steel plunger forming the core of two adjacent mica-insulated coils, which, when alternately excited, give the plunger its reciprocating motion; provision is made for slowly revolving the plunger. Instead of switches, a special single-phase alternator is used, having a drum-armature with a loop-winding, one of whose ends goes to a solid collector-ring connected to the common terminal of the coils of the drill, while the other terminates in a half-ring, which alternately shifts the current into the two sides of the drill-circuit by means of two brushes diametrically opposed to one another. The circuits are so arranged that the magnetism in the plunger is never reversed. The speed of the drill is usually about 380 strokes per minute, each stroke corresponding to one revolution of the generator. The whole apparatus is designed for mule-back transportation. E. H. C.-H.

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558. *Electrical Heating and Lighting.* (Elettricità, Milan, 17. pp. 71–73, 1898.)—The paper affords some interesting figures relative to the cost of electrical heating. The following comparison well illustrates the relative economics of electric lighting and heating:—50 litres [1·76 cub. ft.] of gas produce in a fish-tail burner 4, or in an incandescent burner 20, candle-hours. The same amount of gas transformed into electric energy by means of a gas-engine and dynamo produces 16 candle-hours. The calories [large] given out by the same 50 litres are, directly 225, electrically 45. A kettle taking 550 watts boils 1 litre [1·76 pints] in 12 min. at a cost of 0·66*d.* at 6*d.* per B.T.U. A stove will maintain a room at a temperature of 22° C. above the outside temperature, supposing the air to change once every hour, with a consumption of 65 watt-hours [costing 0·39*d.*] per cub. metre capacity of room. As a measure of the surface required for a given radiation: an iron plate, inside temperature 250° C., outside 200° C., in air at 15° C., will radiate 1 kilowatt [860 calories per hour] with a surface of 0·13 sq. metres. G. H. BA.

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559. *Electric Locomotive Headlights.* (West. Electn. 22. p. 92, 1898.)—This apparatus is a combined engine, dynamo, and arc-lamp, taking up a space 26″ × 18″, and weighing 250 lbs. The engine is a compound steam-turbine running at 1800 revs. per minute; the turbine-wheel, shaft, and armature run in two bearings only and weigh 42 lbs. No details are given as to steam-consumption, or of the construction of the turbine or its governor. A longitudinal section and some photographs of the apparatus are given in the original paper. C. K. F.

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560. *Electrically-operated Power Dredges.* (Elect. World, 31. pp. 291-293, 1898.)—One of the most trying applications of power-developing machinery of any kind is that to power dredging and shovelling apparatus. A complete equipment of this kind, using electric motors throughout, has been developed by the Bennett Amalgamator Manufacturing Company, and put to use in Colorado in placer-mining work. By means of three motors the turn-table carrying the boom and dipper can be turned about a vertical axis, the dipper handle can be raised or lowered through the boom, and the dipper itself can be rotated about the joint of the dipper handle and boom. In operation the turn-table is swung to a suitable point for scooping up a dipperful of gravel. The dipper is lowered until its handle is about in a vertical line, when the bottom closes with a bang and latches automatically; the dipper is then run down in the gravel, and is pulled up and forward by the hoisting cable, thus scooping up a load of earth. The turn-table is then swung until the dipper hangs over the hopper of the amalgamator, which is driven by a motor mounted on the platform of the car, the power being transmitted by means of a heavy steel sprocket-chain.

In connection with the amalgamator a motor-driven pump is employed which is capable of delivering 1600 gallons of water per minute under 100 pounds pressure. Another motor of 15 horse-power is placed on the car-body, and connected with a centrifugal pump which receives the overflow from the amalgamator-tank. The power is supplied by a 150-kilowatt dynamo. The motors are all run at 500 volts. The whole arrangement is so simple that one man can manage it. W. G. R.

DYNAMOS, MOTORS, AND TRANSFORMERS.

561. *Dynamos of Recent Design.* **C. F. Guilbert.** (Écl. Électr. 14. pp. 361–367, 1898.)—The author gives an illustrated description of the following new types of continuous-current dynamos:—(1) A Ferranti machine with external revolving field-magnet and brushes, and stationary armature. The field-magnet consists of a ring of iron with inwardly-projecting pole-pieces on which are wound the exciting coils. Into this ring is fitted another—the pole-ring—which is slotted to receive the compensating winding and to furnish reversing pole-pieces; whereby the machine is enabled to work with constant lead without sparking. (2) A variable-speed motor, designed by J. V. Sherrin, in which both field-magnet and armature are made movable. By applying a brake to the field-magnet, the armature speed may be varied. (3) A unipolar dynamo due to F. E. Elmore. The armature consists of a solid cylinder of iron which passes through the ring-shaped pole-piece of the field-magnet, and which is provided with two collars (one on each side of the field-magnet) from which the current is collected by a large number of balls which run in grooves between the collars on the armature-cylinder and two pairs of fixed collars arranged on either side of them; the frictional losses, which in this type of machine are usually heavy, are thereby materially reduced. The magnetic flux passes radially into the cylinder, then divides, one half going axially along the cylinder in either direction, and then emerging radially once more into a ring-shaped pole-piece which is bolted to the bed-plate and which completes the magnetic circuit. (4) A. W. Smith's dynamo, characterised by the peculiar arrangement of the field-winding, the extreme lightness of the field-magnet, and short air-gap. [A full description of this machine by the inventor will be found in 'The Electrician' for Oct. 8th, 1897.] (5) A constant-potential, variable-speed dynamo, patented by C. H. Wade, J. Moores, and H. O. Farrell, which is intended for the lighting of vehicles or carriages while in motion. The armature-coils are not connected direct to the commutator, but through an arrangement of multiple-contact switches by means of which the number of active turns in each armature-coil may be varied. The multiple-contact switch is actuated by a centrifugal governor in such a manner that more turns are thrown into the circuit as the speed decreases. (6) Several alternative forms of chord-winding due to S. G. Brown (and similar to Mordey's). (7) A six-pole drum-wound dynamo by the Compagnie de l'Industrie Électrique de Genève, in which the field-magnet is annular in shape, and is provided with a single exciting coil. The outer portion of the annular field-magnet is furnished with three pole-pieces (of same polarity) projecting in an axial direction and spaced 120° apart, the magnetic circuit being completed through the armature-core and a solid cylinder of iron which supports it. A. H.

562. *Parallel Operation of Compound Dynamos.* **G. T. Hanchett.** (Elect. World, 31. p. 220, 1898.)—A compound dynamo is wound so that the field-excitation increases with the load on the machine in order to compensate for drop of voltage due to (1) reduction of the speed of the dynamo: (2) the internal resistance of the machine; (3) the demagnetising action of the armature-currents; and (4) the resistance of the conductors from the dynamo to the point at which constant potential is desired. It follows that compound dynamos coupled in parallel and unequally loaded will fail to regulate for line loss with accuracy. This could be remedied by having in addition to the usual series coil, a separate series coil carrying only the main current, or a portion of it. If the main current is not too large, the separate series coils of the several machines could all be placed in series with the line, but in the case of a heavy line-current they would be coupled in parallel. These coils would be permanently in the circuit and would serve to give the initial excitation. W. G. R.

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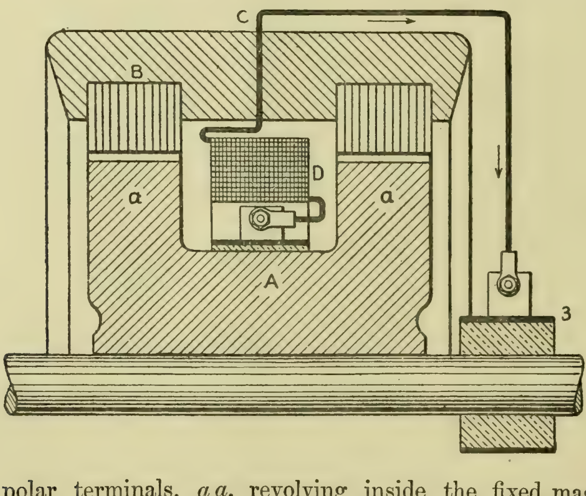
563. *Routin's Self-Exciting Alternator without Commutation.* (Elect. World, 31. p. 182, 1898.)—This is a method, due to J. L. Routin, of obtaining the excitation current for alternators without the use of exciters or rectifiers of any sort. The application particularly described is that of an inductor alternator of the type shown in the accompanying figure, where A represents the rotor



with polar terminals, *a a,* revolving inside the fixed magnetic return, B, on the laminated annular projections of which the induced coils are wound. The poles may be axially in line with each other, or staggered, and the machine may be either single or multiphase. The line C shows diagrammatically the course of the conductors in which the exciting current is generated by the unipola ac tion of the rotating magnetic field in the fixed magnetic

yoke B. This conductor, C, leads from the brushes bearing on an external collector-ring shown at the right-hand end of the shaft, through the core B, to and through the field-winding D, and thence to an internal collector-ring on the rotor A, the two collector-rings being connected either by an insulated conductor or the iron mass itself. W. G. R.

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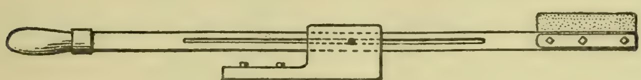
564. *Sand-papering Generator Commutators.* (Street Rly. Journ. 14. p. 13, 1898.)—This is a description of a device due to J. D. Lynch of Hestonville, by which holding sand-paper against the commutator by hand is avoided. The arrangement consists of a bracket of wrought iron $\frac{3}{8}$ in. thick, held against the pillar-block of the engine by four lag-screws. Inside this bracket a long iron bar with forged lever and slot running almost its entire length is held by means of a bolt. The sand-paper is fastened to a wooden block at the end of this bar. The method of holding the bar in the bracket keeps the sand-paper in a plane at right angles to the diameter of the commutator, so that the surface of the



ELEVATION OF DEVICE FOR SAND PAPERING COMMUTATORS

latter will always be flat. The accompanying figure is an elevation of the device. W. G. R.

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565. *Windings of Polyphase Armatures.* **J. P. Stone.** (Amer. Electn. 10. pp. 10–11, 1898.)—The most interesting part of this paper is on the choice of armature windings according to the requirements of the machine. In some cases the triangle-winding is preferable, and in others the star-winding. The latter adapts itself more readily where rectified current is used for compounding, since the commutator can be connected to the common junction of the three phases. The triangle-winding is essential in generators which shall combine direct-current output or input with alternating-current output or input, such as a rotary converter, where, on account of the direct-current feature, the winding must be of the triangle form. Also, by choice of one or the other winding it is often possible to make a better motor both mechanically and electrically. An armature designed for a given working voltage, measured between the lines, would, if planned for star-winding, have fewer turns of larger wire than if intended for triangle-winding. The triangle-winding, on the other hand, has more turns of small wire, as the current is diminished while the E.M.F. in each coil is the full E.M.F.

between the lines. This property is useful under certain conditions, as it makes the E.M.F. between any two lines somewhat less. W. G. R.

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566. *Starting of Non-Synchronous Single-Phase Motor.* **G. B. Maffiotti** and **F. Pescetto.** (Elettricista [Rome], 7. 3. pp. 53–59, 1898.)—The paper treats of the Brown type of motor, which the authors consider as a rotary-field motor, the second component of the rotary field being induced by the armature field. The following problem is proposed :—Given the maximum torque the current being constant, and given the torque required at starting, to find the best value of the resistance in the armature circuit: the best value being that for which the initial speed required to start the motor is a minimum.

Taking the formula

$$k = \pi . \mathrm{N} . \mathrm{B}^2 . \mathrm{A}^2 . \left\{ \frac{r(n-m)}{r^2+4\pi^2\mathrm{L}^2(n-m)^2} - \frac{r(n+m)}{r^2+4\pi^2\mathrm{L}^2(n+m)^2} \right\},$$

where k is torque, n speed of rotation of field, and m that of armature; the curve is plotted between k as ordinate and m as abscissa, and the envelope of this curve for varying armature-resistance, r, is found to be a straight line through the origin and through the point of maximum torque at maximum speed, when $m=n$. The point on the line corresponding to the initial starting torque required gives the minimum initial speed which must be given to the armature; and from this may be calculated the resistance in the armature circuit corresponding to the curve touching the line at this point. Since at the lower torques the ordinate of the point of contact is less than the maximum ordinate of the curve, the motor, once the minimum initial speed has been given, is on a rising curve and will run up speed till it passes the maximum and reaches a stable point. Resistance can then be cut out of the armature circuit until the maximum torque has increased to its normal value. G. H. Ba.

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567. *Alternate-Current Motors.* **L. B. Atkinson.** (Engineer, 85. pp. 218–219, 1898.)—The author divides alternate-current motors into four classes:—(1) Conductive motors, in which the energy is conveyed to the armature through brushes. (2) Inductive motors with brushes, having one inductive electric axis and one magnetic axis: in these the energy is supplied to the armature through the air-gap. (3) Inductive motors with brushes, having two reciprocal inductive electric and magnetic axes. (4) Inductive motors without brushes, having short-circuited coils and two reciprocal inductive electric and magnetic axes: this is the modern induction-motor.

The monophase induction-motor was evolved from such motors by eliminating the supply on one phase whilst running. Asyn-

chronous motors can be used as generators and motor-generators. Passing on to the question of design, the author gave a formula for determining the proper loading of the armature, and derived all the other dimensions of the motor therefrom. Tests, curves, and data of actual motors of the different classes are given. Also curves showing relative weights of motors for continuous current and for single-, two-, and three-phase currents.

E. H. C.-H.

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568. *Applications of Alternating Motors.* **A. G. Davis.** (Elect. World, 31. pp. 25–28, 1898.)—The author considers generally the application and working of alternate-current motors.

W. R. C.

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569. *Graphical Determination of Transformer Efficiency.* **A. Russell.** (Electrician, 40. pp. 720–722, 1898.)—The paper contains an account of a useful graphical method of determining the efficiency of a transformer at various loads from the following data :—

V_1 = primary P.D.

W_0 = watts absorbed by transformer on open secondary.

$Q = R_1 + R_2 \frac{S_1^2}{S_2^2}$, where R_1 and R_2 denote resistances of primary and secondary coils, and $\frac{S_1}{S_2}$ = ratio of turns in primary and secondary respectively.

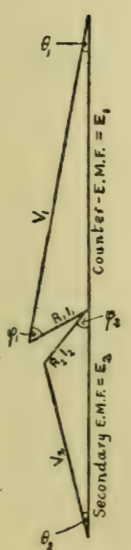

FIG. I.

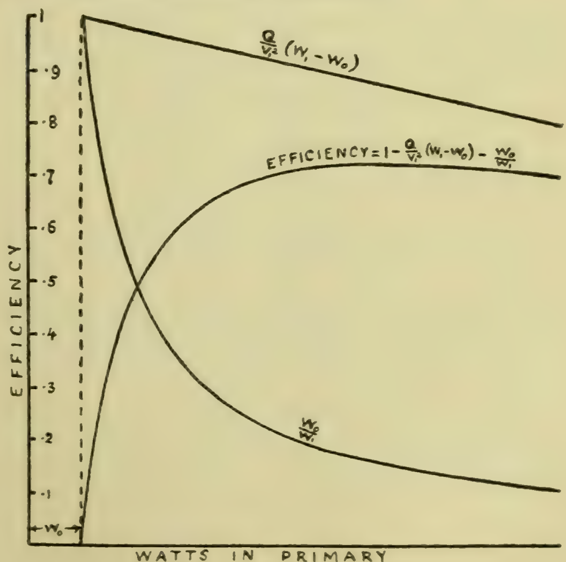

FIG 2.

Referring to Fig. 1, in which I_1 and I_2 stand for primary and secondary currents respectively, we see that, neglecting magnetic leakage,

$$E_1 = \frac{S_1}{S_2} E_2,$$

and that $\cos \theta_1$ and $\cos \theta_2$ are practically each $=1$; so that

$$V_2 + R_2 I_2 \cos \phi_2 = \frac{S_2}{S_1}(V_1 - R_1 I_1 \cos \phi_1). \quad . \quad . \quad . \quad (1)$$

The magnetising turns remaining practically constant, it follows that

$$I_2 \cos \phi_2 = \frac{S_1}{S_2}(I_1 \cos \phi_1 - I_0 \cos \phi_0),$$

where I_0 and $\cos \phi_0$ refer to the primary current and power-factor on open secondary. If W_1=watts supplied to primary, the last equation may be written

$$I_2 \cos \phi_2 = \frac{S_1(W_1 - W_0)}{S_2 V_1}. \quad . \quad . \quad . \quad . \quad . \quad (3)$$

From (1) and (2) we find

$$V_2 = \frac{S_2 V_1}{S_1}\left\{1 - \frac{QW_1}{V_1^2} + \frac{S_1^2}{S_2^2} R_2 \frac{W_0}{V_1^2}\right\} \quad . \quad . \quad . \quad (4)$$

Since in any commercial transformer the term $\frac{S_1^2}{S_2^2} R_2 \frac{W_0}{V_1^2}$ is very small (being generally much less than ·001), we may write

$$V_2 = \frac{S_2 V_1}{S_1}\left\{1 - \frac{QW_1}{V_1^2}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Hence we find, using (3) and (5),

$$\text{Efficiency} = \frac{V_2 I_2 \cos \phi_2}{W_1} = 1 - \frac{Q}{V_1^2}(W_1 - W_0) - \frac{W_0}{W_1}.$$

From this last equation follows the graphical construction shown in Fig. 2, in which the losses have been greatly exaggerated in order to accentuate peculiarities in the shape of the efficiency-curve.

A number of examples are given showing very close agreement between the efficiencies determined by the above graphical method and those actually observed. The method is therefore useful as a means of checking experimental results. A. H.

570. *Rotary Transformers.* **J. E. Woodbridge** and **C. T. Child.** (Elect. World, 31. pp. 216–218, 1898.)—This is a continuation (see Abstract No. 204) of the investigation of the heating-effect of the currents in a rotary converter, the two-phase rotary being now dealt with.

If C is one-half the direct current through the brushes, V the direct voltage between the brushes, then

V = maximum instantaneous alternating voltage;

$\frac{V}{\sqrt{2}}$ = virtual alternating voltage between diametrically opposite collector-rings;

$\frac{C}{\sqrt{2}}$ = virtual alternating-current in either phase (assuming a power-factor of unity);

C = maximum instantaneous alternating-current in one phase; and

$C\sqrt{2}$ = maximum instantaneous combined alternating-current in the armature winding.

If ϕ is the angular distance between the middle point P of a quadrant of the armature and one of the direct-current brushes, and a the angular distance between any conductor on the active surface of the armature and the point P, the direct-current in it is C and the instantaneous alternating-current $\sqrt{2}C \sin\phi$; hence the rate of heating is

$$\{C - \sqrt{2}C\sin\phi\}^2 r = C^2 r(1 - 2\sqrt{2}\sin\phi + 2\sin^2\phi),$$

where r is the resistance of the conductor. To find the total effect during one-half a rotation, this expression must be integrated between the limits

$$\phi = a \quad \text{and} \quad \phi = \pi + a;$$

whence the average heating-effect is

$$C^2 r\left(2 - \frac{4\sqrt{2}}{\pi}\cos a\right).$$

The ratio of this heating-effect in the conductor under consideration to the heating, if the machine was generating the same direct-current load, is therefore

$$2 - \frac{4\sqrt{2}}{\pi}\cos a.$$

To get the average heating-loss throughout the armature, a second integration must be performed with respect to a between the limits

$$a = \frac{\pi}{4} \quad \text{and} \quad a = -\frac{\pi}{4},$$

and the result divided by π: thus

Average heating-loss throughout the armature

$$= \frac{1}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} C^2 r\left(2 - \frac{4\sqrt{2}}{\pi}\cos a\right) da$$

$$= 2 - \frac{16}{\pi^2}$$

$$= 0{\cdot}38.$$

Thus, under the conditions assumed, any direct-current machine used as a two-phase rotary, will dissipate as $C^2 r$ armature-loss only about 38 per cent. of the energy wasted when working as a generator at the same output. If K is the safe transforming capacity for such a machine, then

$$0{\cdot}38\, K^2 r = C^2 r,$$

or

$$K = 1{\cdot}62\, C.$$

Hence, with power-factor unity, the rating of a two-phase rotary transformer may be 62 per cent. greater than that of a direct-current generator or motor of the same dimensions. W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

571. *Motive Power from Tides.* **P. Bunet.** (Électricien, 15. pp. 114-115, 1898.)—An attempt has been made at the little port of Ploumanach (Côtes-du-Nord) to utilise the tides for motive purposes. This has been rendered the easier since at high tide the water overflows into some natural pools at a much lower level separated from the sea by a kind of bank. This drop of water is used to drive a waterwheel to which a dynamo is geared. By the use of accumulators a constant supply of electrical energy is thus available. W. G. R.

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572. *Transmission Plant of the Apple River Power Company.* (Elect. World, 31. pp. 186–188, 1898.)—At the small town of Somerset on Apple River, Wisconsin, an electrical plant has recently been installed for the purpose of transmitting electrical energy 7 miles to New Richmond, where are located a number of mills which had hitherto been using steam-plants for the power they required. The city is also electrically lighted, and the Apple River Power Company, before it began operations, obtained a contract for doing all the city lighting and pumping for the city water-supply, besides several contracts for power for mills, elevators, etc.

The water-wheels installed are of the most improved horizontal type, designed to run at 130 revolutions per minute and to develop 231 horse-power on an 18-foot head, with an efficiency of 80 per cent. The turbines are twin 42-inch machines, by which the end-thrust is neutralised, mounted on a horizontal 6-inch shaft, and discharging into a double quarter-turn cast-iron central draft-chest fitted with a draft-tube 7 feet in diameter and 8 feet long running into a wheel-pit 12 feet deep. The electrical apparatus consists of one 250 kilowatt, 6000 volt, three-phase alternator of the inductor type; two $2\frac{1}{2}$ horse-power 125 volt exciters; one 100, one 50, and one 30 horse-power two-phase brushless-type motors; one 25 horse-power brush-type motor; five 50 kilowatt and two 25 kilowatt 5500 volt three-phase to 220 volt two-phase, self-ventilating oil-transformers; and six sets of 6000 volt Wurts combination choke-coil non-arcing metal lightning-arresters.

The full potential of transmission is generated in the alternator, so that transformers are used only at the distributing end of the circuit to reduce the voltage from 5500 to 220 volts, and are specially designed with a lead from the middle of the secondary wires. The two outside transformer terminals are connected with the old Edison 220 volt outside wires, and the extra lead from the

transformers to the middle wire of the Edison system, allowing the use, as before, of 110-volt lamps without any further change in the system that was already installed. W. G. R.

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573. *Electric Transmission in a Lithographic Establishment.* (Amer. Electn. 10. pp. 1–9, 1898.)—In this article the electrical installation of the American Lithographic Company of New York is described at length, and the special advantages of the electrical system in this connection are discussed. The generating plant consists of two 200 kw. dynamos coupled direct to Corliss engines, and one 40 kw. set; the larger dynamos have smooth-core armatures with disc commutators and ten-pole fields, compound wound for 1740 amps. at 115 volts, 120 revs. per minute, and weigh 24,500 lbs. each. The lighting and power circuits are supplied by separate feeders, protected by armoured conduits, and run in roomy wire-ways specially provided for the purpose. About 140 motors are used, varying in size from 2 to 35 H.P., and having a total capacity of 847 H.P.; slow speed and direct coupling are used throughout. The motors driving the presses are of the ironclad series-wound type, supported from the press frame by cast-iron brackets, and are provided with heavy fly-wheels and electric brakes. A separate controller is used for each motor, giving 5 speeds by varying the field-winding; certain machines are also fitted with push-buttons and relays for stopping the motor in case of urgency. Groups of small machines used intermittently are driven by belts from short lengths of shafting; the motors for this purpose are suspended from the ceiling girders and are shunt-wound, with one speed only. Each motor is provided with an automatic cutout, which in the case of the shunt motors places the starting-switch in the "off" position if the circuit is opened. The presses are lighted with enclosed arc lamps, by means of which colours can be matched as well as by daylight.

The plant has been at work for 6 months with perfect success; the average load is 0·54 of the maximum, and the load-factor 17·6 per cent. The consumption of coal averages 4·45 lbs. per E.H.P. hour. The cost per unit of manufactured product shows a saving of 44·2 per cent. of the cost in former years.

The article is fully illustrated, and a sheet of details drawn to scale is inset. A. H. A.

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574. *A Recent New England Railway.* (Street Rly. Journ. 14. pp. 151–155, 1898.)—This article describes the Torrington and Winchester Street Railway, a country line of $13\frac{1}{2}$ miles of single track, put into operation on July 1, 1897. Full abstracts of the specifications are given under the headings Track and Overhead Construction, Power Station, Engines and Generators, Boilers, Power Station Apparatus, Car Equipment, Cars. The total cost

of equipment and construction up to date is 363,000 dollars, including 13,000 dollars for a Park, etc. The earnings of the 5 closed and 8 open cars for the first 6 months were 25,000 dollars.

E. H. C.-H.

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575. *Paderno Electric Transmission.* (Elettricità, Milan, 17. pp. 133–136, 1898.)—The paper gives a description of the three-phase generators erected in the power-transmission station at Paderno, and explains the reasons determining the choice of type and system.

The 2160 H.P. machines, constructed by Brown, Boveri & Co., generate directly at 13,500 volts with a frequency of 42 periods, their speed being 180 revs. per min. The type with rotating field-magnets was selected in preference to the inductor type of machine, on account of the latter's large magnetic leakage and consequent large internal reaction, which, for a joint supply of light and power, renders regulation difficult. The internal reaction of the existing machines is guaranteed to be not over 5 °/₀ on non-inductive load, and 16 °/₀ on an inductive load with power factor of 80 °/₀. The efficiencies in the two cases are respectively 95 °/₀ and 93 °/₀.

To mention a few structural details:—The armature is capable of rotation so as to bring any portion into a convenient position for repairs. The windings are passed through tubes of micanite-paper, these tubes projecting 10 cms. beyond the iron to guard against discharges to the carcass. The field-magnet consists of 28 cast-steel poles on the periphery of a fly-wheel, each pole being surrounded by a single thick copper helix, with paper insulation between the spirals.

G. H. Ba.

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576. *Alternating Current Regulation.* (Elect. World, 31. pp. 218–219, 1898.)—The difficulty in regulating the voltage at an alternating current station which supplies current for induction-motors and other inductive apparatus is well known. Messrs. Steinmetz and Rice have taken out a patent for an arrangement by which leading currents are introduced into the line to such an extent as to neutralise the lagging component caused by the inductive apparatus connected with the mains. The arrangement is based on the known fact that an induction machine, when driven at a speed greater than that corresponding to synchronism with the main current, acts like a condenser and superimposes a leading component on the main current. By proper adjustment this leading current can be made to balance any lagging current present. The induction-machine is connected to the mains as a motor, and then mechanically driven at a greater speed than corresponds to synchronous running.

Another patent recently taken out by E. W. Rice, Jun., depends upon the known fact that a highly excited synchronous motor acts like a condenser and produces leading wattless currents. W. G. R.

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577. *Dover Traction and Lighting Station.* (Lightning, 13. pp. 95–97, 1898.)—This is an account of the combined traction and lighting station at Dover. For lighting purposes alternating current is generated at 2000 volts and transformed down to 100 velts. The total capacity of the alternators is 325 kilowatts. The arc-lamps are suspended from light arches thrown across the streets, which are narrow. The Parade was illuminated last season by strings of incandescent lamps suspended from wires looped along the Front.

The traction-plant consists of two 100-kilowatt General Electric six-pole dynamos coupled direct to horizontal McIntosh and Seymour engines. The voltage is 500 and the speed 235 revolutions per minute. There is also a 30-kilowatt motor-alternator wound for about 2000 volts and 100 periodicity on the alternator side, and 500 volts on the continuous side. This machine is to be used if required to run one or two cars late at night when the traction-plant has ceased running. W. G. R.

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578. *Polyphase Motors in Electric Traction.* **C. P. Steinmetz.** (Elect. World, 31. pp. 20–21, 1898.)—After some general remarks upon the relative advantages of direct-current motors, used in conjunction with rotary transformers, and polyphase motors, the author goes on to consider the control of the latter. Three methods are available:—(1) Rheostatic control; (2) tandem-multiple control; (3) potential regulation, with short-circuited armature. The advantages and disadvantages of rheostatic control are the same as on the direct-current system. This also applies to tandem-multiple control. Potential regulation is the simplest method, the impressed E.M.F. being varied by means of a transformer of variable transformation. Unfortunately, in this case, the motor efficiency is lower than that with rheostatic control, and the torque per ampere is very low at starting. Unless the drop in the line is very small, the motor is liable to fail to start. Thus this method is generally unsuitable for railway-work. The author concludes with a brief summary of the advantages and disadvantages of polyphase motors as compared with direct-current motors for traction purposes.

W. R. C.

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579. *Electric Traction in Kansas City, U.S.A.* (Street Rly. Journ. 14. pp. 67–72, 1898.)—The Metropolitan Street Railway Company of Kansas City operates 136·5 miles of single track, of which about 71 miles are electric lines, the remainder being worked almost entirely on the cable system. There are four electric generating stations, the most modern of which is described in detail. This station furnishes power to 77 cars, as well as to the workshops $2\frac{1}{2}$ miles away; the average output and cost of working per month for four months in 1897 are given as follows:—

Kilowatt-hours output, 310,338.

Engineers, oilers and firemen	$471·77
Repairs to machinery	83·35
Oil and waste	40·94
Fuel	870·55
Water	26·91
Miscellaneous	19·09
Total....	$1512·61

Average cost of one kilowatt-hour, $·004874.

One of the cable-lines, $4\frac{1}{2}$ miles long, is operated by a 300 kw. electromotor in a substation, supplied from the principal generating station 1·7 miles distant; the detailed costs of working of this plant and of the steam-plant formerly used are given, and show a saving of $660 per month, or about 64 per cent.

About 5000 cast-welded joints are in use on old rails, with excellent results. In the newer construction 103 lb. rails are used, cast-welded and bonded with copper bonds; the rails are laid on wooden blocks in trenches 20 in. × 12 in. deep, which are then filled up with concrete under and around the rails and topped with granite blocks. A. H. A.

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580. *Electric Traction in Switzerland.* **C. Rochat.** (Street Rly. Journ. 14. pp. 99–103, 1898.)—Notwithstanding the abundant water-power available for Electric Railway development in Switzerland, this mode of traction has not reached an expansion proportional with that in some other countries, principally because there are few large cities in Switzerland, and consequently the need of urban rapid transit has not been felt to any great extent. The electric railways actually in operation in Switzerland have a total length of 110·517 km. The first put in operation, in 1888, was that of Vevey-Montreux Chillon, which had a length of 10·49 km.

A table is given showing the rate at which electric traction has grown in Switzerland since 1888, which shows that the principal increase has been in the last three years. Every indication is that in two years the length of electric track will be double that at present.

Considering the kind of motive power at the central stations, the Swiss tramways can be subdivided as follows:—

15·593 km. or 14·2 % are operated by steam.
71·176 km. or 64·5 „ „ water-power.
23·748 km. or 21·3 „ „ gas-engines.

The total capital invested at the end of 1896 in electric tramways was 16,455,801 fr. for 81·614 km. of lines, or on an average 201,664 fr. per km. of line.

To facilitate comparisons the principal data of the Swiss tram-

ways are given together in two tables, of which the following is an abstract:—

Location of Tramway.	Length in km.	System of Trolley.	Gauge in metres.
Vevey-Montreux	10·49	Shuttle.	1
Sissach-Gelter Kinden	4	Wheel.	1
Grütsch-Mürren	4·279	,,	1
Stansstad-Stans	3·455	Sliding shoes.	1
Chavornay-Orbe	4	,, ,,	1·435
Genève	20·010	,, ,,	1·435
Zurich Ville	4·52	Wheel.	1
Zentrale Zürichberg	3·53	,,	1
Bâle	8·66	Sliding bow.	1
Lugano	4·494	Two wheels.	1
St. Moritz	1·64	Wheel.	1
Aubonne Allaman	2·60	Sliding shoe.	1
Lausanne	10·844	,, ,,	1
Chaux de Fonds	1·35	Sliding bow.	1
Alstätten-Berneck	11·565	Wheel.	1
St. Gall	9·190	Sliding bow.	1
Neuchâtel	5·268	Wheel.	1
Fribourg	1·460	Sliding shoe.	1
Zurich-Oerlikon	5·500	Wheel.	1

The tramway and railway lines actually in construction at the present time number twelve, with a length of 103·060 km. The lines for which franchises have been granted, but which are not yet in course of construction, number 25 with a length of 322·705 km.

The author deals with the general character of the construction of the lines under different headings:—

Track Construction.—Information is given relating to types of rails and gauge. The track-switches employed are of two types—those with one movable point and those with two. Each of these types is manufactured automatic and non-automatic. General practice is in favour of automatic switches with two movable points, which give an easy passage to the car and one without shocks. The usual minimum space allowed between the outside of the car and stationary objects along the track, such as houses, trees, etc., is 1 m. An exception, however, has been made in favour of the poles for supporting the overhead wire, and the authorities permit for this a minimum clearance of ·6 metre.

Overhead Construction.—This is varied according to the system of contact employed, viz. trolley wheel, rubbing bow or shoe. A number of views are reproduced in the course of the article which give a good idea of the various modes of construction. Useful information is given with regard to trolley-wires and regulations relating to its installation. Also to the types of insulators employed, to lightning arresters, and to telephone disturbances.

Current and Voltage.—Up to 1895 continuous current only was employed in Switzerland, as elsewhere, for electric tramways. Since that time the tri-phase alternating current has come to

practical use, and installed for the first time at Lugano. The potentials which have been used up to the present have been 550 for the continuous and 450 for the alternating. This year, however, several Lines of considerable length are making a study of the question of voltage, and, after a consultation with the Government Railway Department, a new law was adopted in 1897 by which this voltage has been increased, the maximum being fixed under three different headings. The question of proper voltage was debated to a great extent, and the passage of the law was preceded by a number of tests carried out by Prof. H. F. Weber, of which details are given, to determine if possible the voltage dangerous to the human body. These decisions, which have now become law, will permit an important saving in the construction and operation of electric railways. L. J. S.

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581. *The Steel* 30 *H.P. Traction-Motor.* (Street Rly. Journ. 14. p. 59, 1898.)—This motor is remarkable for its light weight—1200 lbs. only. The motor is of the cast-steel enclosed type, with 4 poles of laminated wrought iron; the frame is in two parts joined by links. Four field-coils are used, wound on formers and held in spring holders. The armature is of small diameter, with a hollow core, and is wound with 33 coils in as many slots; the wires are driven into slots in the commutator lugs, without the use of solder. The motor is primarily intended for electric traction; other sizes are made, from 25 H.P. to 150 H.P. A. H. A.

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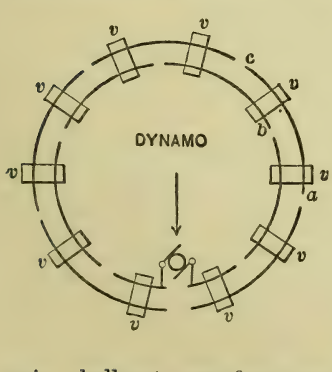
582. *High-tension Direct Current Traction.* **A. Blondel.** (Elect. World, 31. pp. 21–23, 1898.)—The author proposes to employ direct current for long-distance traction by running the trains in series. For this purpose the conductors are erected in sections, as indicated in the figure. Two conductors are, of course, necessary in this system, and the breaks are made alternately so that any break in one conductor is opposite the centre of the section of the other. Calling *ab* one section of the line, then the circuit is complete so long as one train, indicated by v, is upon each section, and thus all the trains will be working in series. A difficulty occurs in maintaining the continuity of the circuit as a train passes from one section to the next. This, however, may be overcome by arranging that a train shall not pass from any given section until a second one has run on to it: in other words, the number of sections must be less than the number of trains running at any time.



When two trains get on one section they each only receive half the normal current, which might result in a slowing-down or even stoppage. It would therefore be necessary to employ two groups of motors on each train to be put in series, or motors with two windings. Change in headway, say to double the number of trains, would be effected by doubling the current and running two trains in parallel. The headway could be increased by the use of switches for coupling sections together.

The figure refers to a loop-line only. But a line which is not looped could be worked in the same manner by using four conductors as a flattened loop.

This method of working possesses all the advantages common to a series system. By running eight cars each requiring 500 volts and 20 amperes, with the station at one end, a saving of 50 °/₀ in copper would result. There are no doubt objections to the system, but the advantages are considerable. W. R. C.

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583. *Electrical Repairs of Railway Motors.* **M. R. McAdoo.** (Street Rly. Journ. 14. pp. 11–13, 1898.)—The author having come to the conclusion that the cost of electrical repairs of railway-motors is usually excessive, invited A. B. Herrick to devise a method of simple electrical tests which would indicate completely electrical weaknesses in motors before the occurrence of an actual breakdown.

The method consists in making tests when the controller is (1) on the first point; (2) on the series step on the series-parallel controller, or on the parallel step where a rheostat is used; and then ground connection is removed and the insulation of the equipment is taken. These three tests are sufficient to show whether the equipment is in good condition or not. If these tests show that the motor is faulty, a more detailed test is required to locate the fault. If these inspectional tests are regularly made, an incipient fault will be discovered and rectified at much less cost than would be incurred in rectifying a complete breakdown. The paper contains diagrams of the testing board, with accessories and instructions for use. W. G. R.

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584. *Dublin Electric Tramways.* **H. F. Parshall.** (Engineer, 85. p. 219, 1898.)—As originally designed, the Dublin Southern Tramways installation would not conform to Board of Trade requirements, as it gave a drop of 20 volts in the earth return. The problem was to utilise as much as possible of the machinery already ordered. Three-phase, high-tension alternate-current system was adopted, with motor generators in substations. During nearly two years of operation, the attendance of one boy in each station has sufficed : the low-frequency motors made synchronising easy. Instead of the 20 cars originally contemplated, sixty could now be worked on the line, the fall of potential then being only $3\frac{1}{2}$ volts. The line is commercially interesting, as illustrating the

development of traffic by improved service. The working costs show that, even with the small units, the system is fairly efficient, but the chief claim for it is the ease and reliability of its operation.
E. H. C.-H.

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585. *Electric Tramways at Dover.* (Lightning, 13. pp. 8–10, 1898.)—This is a detailed account of the electric tramway at Dover, which is of the overhead trolley type. The wires are at a height of 21 feet 6 inches above the road. The current is purchased from the Dover Electricity Supply Company (see Abstract 577). The total cost of the undertaking is about £28,200. During the season the takings amount to about £26 per day. The length of the line each way is about two miles, and the fare for the single journey is one penny. The running cost does not exceed £18 per day, so that the undertaking is a financial success. Both electrically and mechanically, everything seems to have succeeded beyond expectations. W. G. R.

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586. *Rail-Bonding.* **E. T. Birdsall.** (Street Rly. Journ. 14. pp. 18–19, 1898.)—The author discusses at length the subject of rail-bonding, and emphasises the necessity of increased cross-section and contact-surface as compared with present practice; he advocates constant inspection and testing in order to ensure the maintenance of the joints in good condition. A bond devised by the author consists of stranded copper conductors with cast copper contact-plates, which are soldered to the underside of the rail-ends; the cross-section is equivalent to that of a 70 lb. rail. This bond costs about $1·25, applied in place. A. H. A.

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587. *Kenway's Overhead Trolley-System.* (Elect. Engin. 21. pp. 333–334, 1898.)—This system aims at reducing the side bracket-arm to a minimum, and increasing the length of the trolley-arm in proportion. Only one trolley-wire is used for single or double track, and contact is made with it on the side by a vertical sliding-bar at the end of the adjustable pivoted trolley-pole. When cars meet, the trolley-arm of the outer car is supposed to be guided over that of the inner arm by star-shaped discs on the vertical sliders, but doubt is thrown on the feasibility of this at high speeds. The inventor has yet to show how convex curves are to be negotiated, and how difficulties due to variation in the relative heights of trolley-wire and slider are to be overcome.
E. H. C.-H.

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588. *Trolley-Car Service on the Brooklyn Bridge.* (Elect. World, 31. pp. 179–180, 1898.)—The construction of tracks and the operation of the Brooklyn electric cars across the great suspension bridge is remarkable on account of its solidity of structure and the ingenious mechanism for controlling the switches and signals. Bonding is effected by a continuous copper cable of 175,000

circular mils section laid in the side-groove of the rail. The overhead construction is of remarkable solidity. The trolley-wire, of "figure eight" cross-section, is supported on flexible pole-brackets, spaced only 37 feet 6 inches apart. The feeder-cables are eight in number, each of 500,000 circular mils, and are carried on heavy glass insulators mounted on small brackets inside the through-trusses in which the car-cables run. Seven of these cables are positive feeders, while one of them acts in conjunction with the rails and rail-cables as a return-feeder. The track-switches are of the well-known variety made by the New York Switch and Crossing Company, and will be electrically controlled by interlocking electric switches in the signal box. It is expected to maintain a headway of 15 seconds with a speed of 7 miles an hour, thus keeping the cars a little over 100 feet apart.

W. G. R.

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589. *High Speed Electric-Truck.* (Street Rly. Journ. 14. p. 167, 1898.)—The Peckham "Metropolitan Special" Truck, which is here illustrated, is designed for extra-long, high-speed cars, being guaranteed to handle 22 ft. closed cars, and 32-ft. open cars at 25 miles per hour without oscillation. The framework is extra strong, and under-tension springs are provided at the ends to check oscillation. 150 of these trucks are running on the Madison Avenue line in New York. E. H. C.-H.

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590. *Trolley Pole-Catcher.* (Street Rly. Journ. 14. p. 59, 1898.)—A device is described for catching the trolley-pole when the trolley-wheel leaves the wire, so as to prevent injury to the overhead construction, etc. The rope attached to the pole is wound on a reel in the catcher, and is held taut by a coiled spring which yields to slow movements; but if the pole rises suddenly, as when the wheel runs off the wire, the reel revolves rapidly and throws out dogs which instantly stop the motion. The catcher is usually fixed on the dash-board of the car. A. H. A.

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591. *Peckham Trucks.* (Street Rly. Journ. 14. pp. 113–114, 1898.)—These swing-bolster double-trucks are described and illustrated. "14 A" is designed for high-speed suburban traffic, and "14 B" for elevated railways with sharp curves. Both aim at keeping the car-body as low as possible to facilitate ingress and egress. The bolster is carried on a spring plank by one half-elliptic and two spiral rest-springs, the plank itself being supported through rubber cushions by four links; these links incline slightly outwards when the car is at rest, and centrifugal force on curves therefore tilts the car, and has the same effect as superelevation of the outside rail. The "14 B" can be made with 45 in. wheel-base, but for 4 ft. $8\frac{1}{2}$ in. gauge, not less than 4 ft. 6 in. wheel-base is recommended. E. H. C.-H.

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592. *Emergency Pavement-Brake.* (Street Rly. Journ. 14. p. 110, 1898.)—This consists of an eccentric spool or cylinder, mounted near the middle of the car, which, when lowered on to the pavement, is revolved by the motion of the car till it lifts the truck-frame about 2 inches, thus bringing nearly the whole weight of the car on to steel brushes, which act on the shaft of the spool. The device is not intended to replace wheel brakes, but is for use in slippery weather, or on steep grades. It does not injure the pavement. E. H. C.-H.

593. *Emergency Brake.* (Street Rly. Journ. 14. p. 113, 1898.)—This brake is specially suitable for a runaway car on a steep grade. By means of bevel gearing, the motor-man can exert about 3000 lbs. downward pressure on a steel fork on the end of a threaded shaft, causing it to enter the ground, one prong on each side of the rail. It is claimed that this will not wreck or derail the car. E. H. C.-H.

594. *Kingsland's Surface-Contact System.* (Elect. Rev. 42. pp. 359–360, 1898.)—Contact-rails or studs are connected on to the main conductor through two switches in series. In their simplest form, these switches consist of two contact-plates and a sliding contact-bar operated by a lever. Each contact-bar rocks between two pairs of contact-plates and controls the circuits of two adjacent studs. The one operation of pushing over the lever disconnects the stud behind from the mains, and at the same time connects the stud in front. For ordinary street work, the sliding contact-bar of the switches takes the form of a cylindrical commutator, which is rocked by an electromagnet, worked as a shunt off the mains. This apparatus is buried in a water-tight box 8×10 inches. Advantages claimed for the system are that the switches have no springs and require no force to hold them in position ; no equipment of cells or electromagnets on the cars is necessary to operate the switches, and should a switch fail to cut-out, the car cannot proceed. E. H. C.-H.

595. *An Improved Sand-box.* (West. Electn. 22. p. 146, 1898.)—The novelty in the "Ham" sand-box of the Electric Appliance Co. of Chicago, is the absence of any valves at the bottom of the box. Underneath the opening of the hopper is a curved shelf, over which a paddle is reciprocated, thus forcing the sand over the ends of the shelf into the feed-spouts. E. H. C.-H.

596. *Electric Car Details.* **E. C. Parham.** (Amer. Electn. 10. pp. 29–30, 1898.)—This article forms one of a series, complete in themselves, dealing with the precautions to be observed in equipping a truck, and the course to be pursued in car-wiring from trolley-wheel to hood-switches. The latter are provided as a means of breaking the circuit, should accident disable the con-

troller: hence are safety devices. After dealing with the wiring of the car, the lightning arrester is considered. In same cases the arrester is tapped-on the trolley-wire before it enters the fuse-box, and in others it is tapped on afterwards: neither method seems to affect the arrester's efficiency.

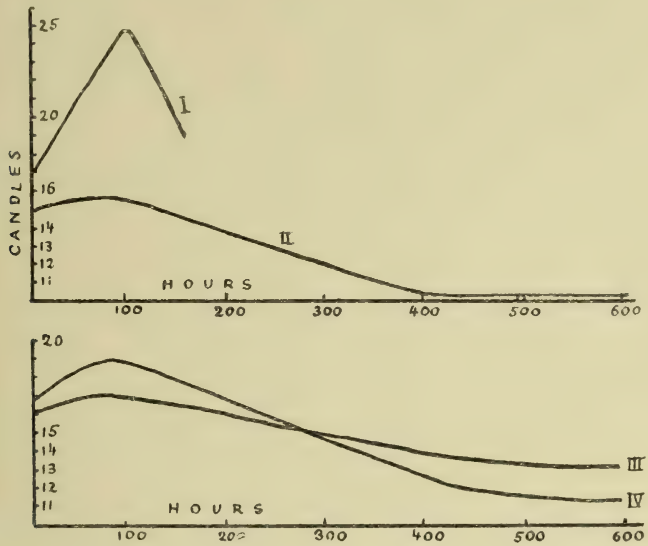
The author gives full notes with regard to the coupling up and installing of controllers, and to the care to be observed in the splicing of joints. In the fixing of connections, it must not be forgotten that upon receiving a load the car-body lowers three or more inches. Also that when wiring a car having radial trucks, the connections must be placed where the car-wheels cannot reach it when turning a curve. When a brake is put on the brake-rods rise, and all wires must be well out of their way. L. J. S.

597. *Changing a Cable-Conduit to an Electric Conduit.* (Street Rly. Journ. 14. pp. 37–39, 1898.)—This is an account of the methods employed in substituting electric traction for the cable system at Washington, D. C., U.S.A. Scale drawings are given, showing the alterations required to adapt the cable conduits to electrical working; these are being made *in situ*. As the slot-rails were unprovided with lips to shed water clear of the electric conductors, a 1 in. × 1 in. angle-iron was riveted to the lower edge of each rail throughout its length; special tools were devised for drilling the holes and holding the rivets in position while being headed. The working conductors are iron T-rails weighing 21 lbs. per yard, bonded together; porcelain insulators are used, cemented into iron caps. A brief account of the generating plant is also given, as well as a more detailed description of the construction of the car-trucks. A. H. A.

598. *Incandescent Lamp-Filaments.* **J. C. Shedd.** (Amer. Electn. 10. pp. 105–106, 1898.)—The paper contains an historical review of the gradual evolution of the modern incandescent-lamp filament. A. H.

599. *Nernst Incandescent Lamp.* **H. Lux.** (Elect. World, 31. p. 335, 1898.)—The paper is a brief account of Nernst's experiments on the use of substances like chalk, magnesia, kaolin, etc. as materials for incandescent-lamp filaments. These bodies may be considered as practically non-conducting at ordinary temperatures. When raised to a high temperature, they become conducting, and are further characterised by the large proportion of visible light-rays which they emit. Nernst has succeeded in obtaining ·96 candle per watt with a hollow filament of magnesia. The greatest difficulty in the way of a practical application of these facts lies in the very poor initial conductivity of the material, which has to be raised to a high temperature by some independent means before it will conduct appreciably. Alternating currents must be used in order to prevent electrolytic action on the material. A. H.

600. *Lamp Life and Efficiency.* **E. F. Gibbon.** (Elect. World, 31. p. 357, 1898.)—The author gives curves, reproduced below, showing the results of a number of tests carried out by him on lamps in actual service. This is a fairer test than one carried out in a laboratory, as the lamp is subjected to the extra strains



arising from fluctuations in the voltage of the mains. Curves I and II refer to lamps which were rated as 108 volt 16 c.p. 56 watt lamps; and curves III and IV relate to 108 volt 16 c.p. 50 watt lamps. The author points out that the lamp to which curve I refers was rated above its normal voltage, the life being only 150 hours. The best result is that indicated by curve III. A high-efficiency lamp would, however, be quickly destroyed on a poorly-regulated circuit. The author emphasises this fact, and recommends the frequent use of portable voltmeters for ascertaining the P.D. at various points of the distributing system. A. H.

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601. *The Lighting of the Place du Théatre.* **J. Reyval.** (Écl· Électr. 14. pp. 461–465, 1898.)—The Place du Théatre-Français is lighted by arc-lamps from an alternating current-circuit, the frequency being 88 complete periods per second. An underground transformer-chamber is established in the square, and contains a large Labour transformer with double secondary circuit, the primary volts being 2400, and the secondary volts 110 on each

circuit. This transformer is provided with two circuit-breakers immersed in oil, a Patin interrupter, and an arrangement for earthing on the Cardew system. The secondary current at 110 volts is divided between two groups, each containing two circuits—a permanent circuit on which the lamps remain lighted all night, and another on which the lamps are extinguished at 1.30 A.M. In the lamp-circuit are placed variable Midoz choking-coils, a type which allows the self-induction to be varied by altering the number of turns of wire. The arc-lamps are all of the Kremenezky type, and are two and two in series on a 110 volt circuit. They consume 14·5 amperes with 33 volts between the lamp terminals, and are enclosed in globes with reflectors placed above the arc, so that the curve of intensities approximates very closely to that of a direct current-arc. The successful lighting of the Place was a difficult matter, on account of the large number of streets running into the square. W. G. R.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JUNE 1898.

GENERAL PHYSICS.

602. *Hardness of Metals.* **A. Föppl.** (Annal. Phys. Chem. 63. 1. pp. 103–108, 1897.)—In these experiments two test specimens of each material are polished to a cylindrical surface 20 mm. radius, then laid crosswise and pressed together in the testing machine. It is found that for each material the surface of indentation is proportional to the pressure applied, and that therefore the specific pressure is a measure of the hardness. The numerical value of the hardness, h, is dependent on the radius of the cylindrical surfaces; the product $h\sqrt[3]{r}$ being constant. A. S.

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603. *Elastic Coefficient of Platinum.* **A. Winkelmann.** (Annal. Phys. Chem. 63. 1. pp. 117–123, 1897.)—The elastic coefficient is measured by observing the deflection of a loaded bar. The object of the work is not so much the exact determination of the coefficient as its variation with time and changes of temperature. Repeated heatings to 400° C. increase the value of the coefficient at 20° C.; with efflux of time, the bar remaining at 20°, the coefficient diminishes. In the experiments recorded the original value at 20° was 16,926; after many heatings to 400° its value was 18,380; at the end of about 10 months' rest the value was 17,516; after an additional rest of about 3½ months (13½ months in all) the value was 17,508. Whether the coefficient would have attained its original value if left undisturbed for a longer period is not known. A. Gs.

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604. *Compressibility of Salt-Solutions.* **H. Gilbault.** (Zeitschr. phys. Chem. 24. pp. 385–440, 1897.)—The determinations at low

temperatures are made by the method of Cailletet, the only modification being the employment of a gilded platinum wire to show the height to which the mercury has risen in the piezometer-tube, instead of gilding the tube itself. At higher temperatures the liquids are compressed in a thick-walled glass tube, the part containing the liquid being heated in a glycerine-bath. Solutions of benzoic acid and borneol in ether and of resorcinol in alcohol are examined. Complete isotherms for a number of temperatures up to the critical point are determined, and from them the critical data obtained. The critical temperature of the solutions is taken to be the temperature at which the volume, u, of the solution when wholly liquid and under the pressure of its saturated vapour becomes equal to the volume, u', which it possesses when the whole of the solvent has just evaporated. The critical temperatures and pressures of the solutions are higher than those of the pure solvents, the values increasing at first very rapidly with concentration. When the concentration is measured by the ratio between the number of dissolved molecules and the total number of molecules in the solution (the molecular weight of the salt being assumed to be half that represented by its formula), the rise of critical temperature and pressure with concentration is independent of the nature of the dissolved substance.

The value of $1/u+1/u'$ is a linear function of the temperature, just as in the case of pure substances.

Neither the formula of van der Waals nor that of Clausius represents the connection between volume and pressure at constant temperature with sufficient accuracy. The empirical formula

$$v = -1/\mathrm{M}k \log(p-\mathrm{A}) + \mathrm{B}p + \mathrm{C}$$

—where v, p, and M are the volume of that quantity of substance which possesses unit volume at 0° and atmospheric pressure, the pressure, and the modulus of common logarithms, and A, B, C and k are constants—represents the results obtained with great accuracy even near the critical temperature and at 200 atmospheres. From this formula the mean and true coefficients of compressibility, $-(v-v_1)/(p-p_1)$ and $-dv/dp$, are easily calculated.

The influence of temperature on the compressibility is represented by the formula

$$-dv/dp = a - b\,p/\pi \Big/ \frac{\theta - t}{273+t} + d\,\frac{p-\pi}{\pi},$$

where a, b, and d are constants, and π and θ are the critical temperature and pressure. The constants a, b, and d have the same values for the solvent and solutions in it; from which it follows that at corresponding temperatures and pressures the solutions and solvent have the same compressibility. Since, as above mentioned, solutions in the same solvent and of equal molecular concentration have the same critical temperature and

pressure, such solutions also have the same compressibility at corresponding temperatures and pressures.

The influence of concentration on compressibility is more fully investigated for aqueous solutions. The mean compressibility between 1 and 300 atmos. at 20° is used; and in order to have comparable numbers the molecular compressibility, μ, is calculated for volumes containing equal numbers of molecules. The molecular concentration is calculated in the same way as before. The formula

$$\frac{\log \mu - \log \mu_0}{a} \frac{d'}{d} = k$$

is found to represent the relation between molecular compressibility and concentration with great accuracy. In it μ and μ_0 are the molecular compressibilities, d and d' the densities of the solution (of concentration a) and of the solvent, whilst k is a constant. Solutions of 18 salts in water are examined, and give results which are very completely represented by the above equation. The values of k are closely connected with the contraction which takes place when 1 gram of the salt is dissolved so as to form an infinitely dilute solution. Calling this σ, the following equation holds good for all the salts examined:

$$\sigma = 1{\cdot}7067\,(k - 0{\cdot}48) + 0{\cdot}15024\,(k - 0{\cdot}48)^2.$$

The same equation applies to a solution of cadmium iodide in alcohol, so that its application would appear not to be limited to water. T. E.

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605. *Electrical Theory of Universe.* (Elect. Rev. 42. pp. 72–74, 138–141, 283–284, 1898.)—This is a somewhat disconnected collection of facts and phenomena which are stated to support the idea of an electrical origin for the various celestial phenomena, and also for the meteorological phenomena of the atmospheres of the earth and planets. C. P. B.

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606. *Slide-Rule for Barometric Corrections.* **B. Sresnewsky.** (Zeitschr. Instrumentenk. 17. pp. 335–338, 1897.)—This instrument is designed for applying various corrections to barometric readings, so as to reduce them to sea-level, standard temperature, and normal hygrometric state, according to the formula of Rühlmann (see Wild's 'Repertorium für Meteorologie,' vol. 10). In order to make these calculations by slide-rule, the formula is somewhat simplified; but the author shows that the simplification does not introduce serious errors. A drawing of the instrument is given. R. A.

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607. *States of Equilibrium.* **F. Wald.** (Zeitschr. Phys. Chem. 24. pp. 509–512, 1897.)—Ostwald has concluded that, when a system leaves one state of equilibrium for another, it is not

the stablest possible that is assumed, but the nearest that is more stable. The author shows that Ostwald's theoretical explanation of this "law" is untenable, and he gives reasons for viewing it only as a "rule," the operation of which is dependent on external circumstances. R. E. B.

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608. *Motion of Liquids.* **M. E. Fontaneau.** (Comptes Rendus, 126. pp. 630–631, 1898.)—M. Fontaneau here states that by a simple transformation of the ordinary equations of hydrodynamics he has shown the existence of a function Π, defined by

$$Lp+Mq+Nr=\Pi,$$

where $p\ q\ r$ are components of stream-velocity, and $L\ M\ N$ components of rotation; and he proposes to integrate that equation for the case in which $\Pi=0$, or the axis of rotation is at right angles to the stream-lines, and he proposes to employ curvilinear biorthogonal coordinates. The analysis is not given in this note. S. H. B.

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609. *Irreversible Processes.* **Anton Wassmuth.** (Annal. Phys. Chem. 62. 3. pp. 522–527, 1897.)—The energy of a system is in this paper denoted by

$$L=\tfrac{1}{2}\Sigma\alpha_{\mu\nu}\dot{p}_\mu\dot{p}_\nu,$$

where $p_\mu\ p_\nu$ are generalised coordinates, and the coefficients "α" are functions of them or constants.

The potential is V; so that

$$\Sigma P_i\partial p_i=-\partial V,$$

P_i being a component of force.

$$F=\tfrac{1}{2}\Sigma b_{\mu\nu}\dot{p}_\mu\dot{p}_\nu$$

is the dissipation-function. Then the μth Lagrange equation gives

$$Q_\mu=\frac{d}{dt}(\alpha_{\mu_1}\dot{p}_1+\alpha_{\mu_2}\dot{p}_2+\&c.)-P_\mu$$
$$+(b_{\mu_1}\dot{p}_1+b_{\mu_2}\dot{p}_2+\&c.)=0.$$

It follows, by the correspondence of dimensions, that

$$a_{\mu_1}=\tau_{\mu_1}b_{\mu_1}\&c.,$$

where τ is the *time of relaxation*; and so

$$\frac{dL}{dt}=\Sigma\tau_{\mu\nu}\frac{dF_{\mu\nu}}{dt}\quad\text{and}\quad\Sigma\tau_{\mu\nu}\frac{dF_{\mu\nu}}{dt}+\frac{dV}{dt}=-2F,$$

and if there be no forces derived from the potential V,

$$\frac{d\mathrm{L}}{dt} = \Sigma\tau_{\mu\nu}\frac{d\mathrm{F}_{\mu\nu}}{dt} = -2\mathrm{F}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (\mathrm{II.})$$

This is, in effect, the same equation as obtained by Natanson (Zeitschrift für Phys. und Chemie, 21. pp. 183–217, 1896).

Herr Wassmuth gives an example:—

The energy per unit of volume in ether shall be assumed to be

$$\mathrm{L} = \frac{\mathrm{K}}{8\pi}(\mathrm{P}^2+\mathrm{Q}^2+\mathrm{R}^2),$$

where P Q R are three mutually perpendicular vectors, and may be

$$\mathrm{P} = \dot{p}_1, \quad \mathrm{Q} = \dot{p}_2, \quad \mathrm{R} = p_3,$$

the time-differentials of three independent generalised coordinates p_1, p_2, p_3.

The potential per unit of volume shall be

$$\mathrm{V} = \frac{\mu}{8\pi}(\alpha^2+\beta^2+\gamma^2),$$

where α, β, γ are connected with P, Q, R by the cyclic relations

$$\mu\frac{d\alpha}{dt} = \frac{d\mathrm{R}}{dy} - \frac{d\mathrm{Q}}{dz} \quad \&c.$$

Also it is assumed that initially we had

$$\alpha = \beta = \gamma = 0.$$

From these data, by the use of the Maxwell-Helmholtz principle of continuity, are derived the cyclic relations

$$\mathrm{K}\frac{d\mathrm{P}}{dt} = \frac{d\beta}{dz} - \frac{d\gamma}{dy} \quad \&c.$$

If there be resistance, we have

$$\mathrm{F} = \tfrac{1}{2}\mathrm{C}(\mathrm{P}^2+\mathrm{Q}^2+\mathrm{R}^2),$$

C being a constant; and hence, if V be constant, follows

$$\frac{d\mathrm{L}}{dt} = -2\mathrm{F}, \qquad \text{as in (II.).}$$

S. H. B.

LIGHT.

610. *Elastic Bodies and Light.* **P. Glan.** (Annal. Phys. Chem. 63. 1. pp. 230–233, 1897.)—This is a continuation of previous mathematical investigations respecting the relations between the elastic properties of bodies and their behaviour to heat- and light-waves. The present paper deals with the absorption-coefficient of a substance for light-waves and its conductivity for heat and electricity. J. L. H.

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611. *Spectroscopy.* **M. Hamy.** (Comptes Rendus, 125. pp. 1092–1094, 1897.)—The author describes an apparatus, founded on the principle of interference, for separating radiations which differ but little in wave-length. J. J. S.

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612. *Star Spectra with Grating.* **C. F. Poor** and **S. A. Milchell.** (Ast. Phys. Journ. 7. pp. 157–162, 1898.)—This paper gives the results of the first really successful photographs of stellar spectra which have been obtained up to the present by the use of a concave grating. In 1892 Crew, at the Lick Observatory, obtained a few spectra by using the grating in connection with an objective, the whole forming a telespectroscope. The present authors use the grating direct, the light being focussed directly by reflection from the concave surface onto the photographic plate. For the experiments described, a small grating with a ruled surface of 1×2 inches was used. This had a radius of curvature of one metre, and had 15,000 lines to the inch. The whole was mounted in a light box strapped to the side of a clock-driven telescope which acted as finder, and the grating so adjusted that the length of the lines were parallel to the equator, this being the most accurate position, as any slight inaccuracy of the driving of the clock will only lengthen the spectral lines and not broaden or blur them. Sirius was the star used at first, and exposures were given ranging from ten minutes to one hour, using the first-order spectrum and Seed's gilt-edge plates. The resulting spectra are 5 cm. long, and vary in width from 0·1 m. to 1·5 mm.

Two plates are given, illustrating the spectra obtained, and these show the best of definition. C. P. B.

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613. *Theory of Diffraction.* **G. Sagnac.** (Journ. de Physique, 7. pp. 28–36, 1898.)—The author treats, by geometrical construction, the case of diffraction of plane waves by a screen pierced with parallel slits. Finally the classical formula is reached, which is established analytically by the aid of integrations and by taking the sum of a series of sines or cosines

of arcs in arithmetical progression. The geometrical method, which furnishes a simple demonstration, gives besides directly the solution of all the fundamental questions relative to diffracted beams. J. J. S.

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614. *Lens Formulæ.* **R. Steinheil.** (Zeitschr. Instrumentenk. 17. pp. 338–344, 1897.)—As an example of the application of the lens formulæ of Charlier, the author calculates the radii of a doublet, being given the constants of the glass and the optical conditions to be fulfilled. To check the truth of the formulæ, the particular case is considered of the object-glass of the heliometer at Königsberg, (1) for yellow light, (2) for violet light. The formulæ neglect the thickness of the lenses; consequently the results are only approximate: they do not compare very well with those calculated by the trigonometrical method of A. Steinheil.

R. A.

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615. *Argon in Röntgen-Ray Tubes.* **H. L. Callendar** and **N. N. Evans.** (Electrician, 40. pp. 394–395, 1898.)—A continuation of experiments made in 1896, using tubes of various types under varied conditions with a very intense current and high vacua. Elaborate details are given, and it is deduced that:—(1) the hydrogen occluded in the kathode plays the part of a carrier of the discharge from the metal to the gas; (2) with sufficient occluded hydrogen, there is little or no sputtering of the aluminium; (3) in absence of hydrogen, the discharge is conveyed by particles of the metal itself, which excite fluorescence and generate Röntgen rays wherever they impinge; (4) in default of extraordinary precautions for drying, and removal of hydrogen from the electrodes, the residual gas is in most cases hydrogen or water-vapour.

Similar experiments are recorded with dry air, hydrogen, oxygen, and water. Hydrogen seemed the most suitable gas for x-ray tubes; but "helium, being also a very light gas, might be equally good."

If the great resistance to the passage of the discharge in the case of argon be due to its monatomic character, it might be expected that mercury vapour would behave in a similar manner. Experiments with inverted U-tubes in which mercury was distilled and exhausted, showed that a very small trace of another gas enormously reduced the resistance; so that, if the vapour could be obtained quite pure, it might not conduct at all. The presence of argon by itself had little, if any, effect on the production of Röntgen rays, since the amount present in the tube could be varied within wide limits.

Another series of experiments, not yet concluded, investigated the apparent absorption of argon. It was observed that a very good vacuum could be obtained by finally absorbing residua water-vapour by phosphoric anhydride. When dry argon was

then admitted to a pressure of 0·160 mm., the tube was filled with blue light and gave the argon spectrum without hydrogen or nitrogen. After half an hour of a direct or alternating current the tube became very black, but there was no change in the pressure. S. G. R.

616. *Röntgen Rays.* **A. Volta.** (Elettricità, Milan, 17. pp. 84–87, 1898.)—This is a note on Prof. Filippo Re's pamphlet ('La teoria dei raggi Roentgen,' Palermo, Reber, 1898), in which, after discussing the various theories of the nature of Röntgen radiation, Prof. Re arrives at the conclusion that the Röntgen rays consist of electric waves of infinite wave-length, or practically so. This explains the great diffusivity, the absence of interference phenomena, the luminescence, the passage round obstacles, the manner of reflexion, the absence of refraction, the photographic action. The theory admits the possibility of polarisation, but is weak in regard to the differences between different Röntgen radiations in respect of their penetrative powers. A. D.

617. *Röntgen Rays.* **G. Adam.** (Elect. Rev. N.Y. 32. pp. 148–149, 1898.)—The author suggests that the molecules driven from the kathode lose their charge and are broken up into atoms at the surface bombarded, and that this is sufficient to account for the conversion of kathode rays into Röntgen rays. A. D.

618. *Law of Emissivity.* **C. E. Guillaume.** (Ind. Élect. 7. p. 69, 1898.)—This is a note on Lummer and Pringsheim's result that Stefan's law of the total radiation varying as the fourth power of the absolute temperature, though at first founded on a narrow range of temperatures, holds good for dead-black radiators from 100° to 1300° C.; the results being more exactly expressed by saying that it varies as the 3·96th power. A. D.

HEAT.

619. *Expansion of Water between* 0° *and* 40°. **P. Chappuis.** (Annal. Phys. Chem. 63. 1. pp. 202–208, 1897.)—A dilatometer, made of *iridium-platinum*, and consisting of a cylindrical tube 110 cm. long and 38 mm. diameter, is employed. The values obtained for the densities only differ by one or two units in the sixth decimal place from those obtained by the same author in 1892, when he employed a *glass* vessel as his dilatometer. A. Gs.

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620. *Comparison of Heat Conductivities.* **W. Voigt.** (Annal. Phys. Chem. 64. 1. pp. 95–100, 1898.)—This is an addition to a previous paper (see Phys. Soc. Abstracts, No. 125, 1897), in which the author explained a new method for determining the relative heat conductivities along the principal axes of a crystal. The method is now applied to determinations of the relative conductivities of two solid bodies. Thin plates are cut, one of each substance, in the shape of right-angled triangles; the plates are cemented with their hypotenuses so as to form a rectangle. The combined plate is coated with a very thin layer of elaïdic acid to which wax and turpentine are added. In such mixtures the acid melts at about 45° C., and solidifies again in tiny crystals, yielding a well-defined isothermal curve. The ratio of the two sides of the triangles is that of the two conductivities to be determined, as fixed approximately by a preliminary experiment. The heating is effected by means of a copper bar at 70° or 90° C., either the short side of the better heat-conductor, or the long side of the poorer conductor being placed against the copper bar. The conductivities are derived from measurements of the angles under which the isothermals cross the common hypotenuse. These angles can be measured within fractions of a degree; a mistake of $\frac{1}{4}$° would cause an error of 2 per cent. in the heat conductivities. Some particulars are given of experiments with three glasses. H. B.

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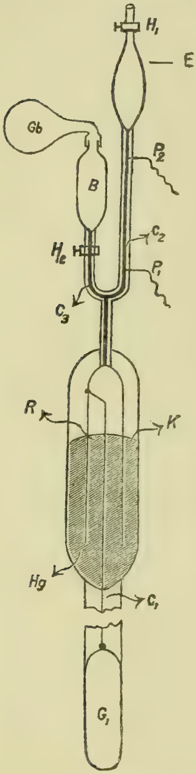
621. *Thermometer-Testing at the Reichsanstalt.* **F. Kohlrausch.** (Zeitschr. Instrumentenk. 18. pp. 76–85, 1898.)—This is a publication of the official regulations under which thermometers are tested and certified at the Reichsanstalt, and also at the branch institution at Ilmenau which is under the control of the Reichsanstalt. The thermometers are distinguished as normal, laboratory, meteorological, clinical, industrial, and domestic thermometers. The Reichsanstalt alone deals with normal instruments; it does not test thermometers for domestic use; other thermometers may be offered at either place. The standard scale for normal thermometers is the hydrogen-thermometer scale of the Bureau International of 1887; for standardising calibrations above 100° C., air-thermometers are used. The paper states the conditions which must be satisfied in order to obtain certificates in the various classes, and also the terms. Thermometers approved are marked

with the German eagle and the letters P.T.R. or G.S. (Ilmenau), and also with a number. H. B.

622. *Thermostat.* **C. Richter.** (Elektrochem. Zeitschr. 4. pp. 155–156, 1897.)—The inventor claims the advantages of portability, cheapness, and accuracy, and by means of the apparatus the required temperature may be maintained to within 0°·1 C. To set the instrument, the bulb G_1 is immersed in the liquid the temperature of which is to be kept constant, while the stopcock at H_1 is open and that at H_2 closed. The air in G_1 expands and forces the mercury in K through the capillary tube C_2 into the chamber E. As soon as a state of equilibrium is reached at the required temperature, the stopcock at H_1 is closed and that at H_2 cautiously opened. The mercury is thus allowed to flow from E into B until the extremity of the thread in C_2 nearly touches the platinum wire P_2. If too much mercury be accidentally run down, the level may be restored by pressing the indiarubber ball G_b. The stopcock H_2 is now closed and the apparatus is ready for use. Should the temperature rise too high, the thread of mercury P_1P_2 completes the circuit of an electrical arrangement by which the gas-supply is cut off, and only a small bye-pass remains lighted. If, on the other hand, the temperature falls, the mercury descends below P_2, the circuit is broken, and the cock of the burner opened by a spring. J. W.



623. *Specific Heat of Refractory Metals.* **H. Mache.** (Wien. Akad. Sitzber. 106. pp. 590–593, 1897.)—The specific heat of the more refractory metals has up till now only been determined in the state of powder, owing to the difficulties of obtaining them in any other form. Moissan has, however, succeeded in obtaining some of these in more compact form by means of his high-temperature furnace, and the author has now determined the specific heat of those so obtained. These are vanadium, wolfram, uranium, chromium, and palladium. Bunsen's calorimeter was used, and the different determinations made with each metal agree to two per cent. The mean values of the specific heats are: Pd. 0·0549, Cr. 0·1208, V. 0·1153, Wo. 0·0336. The values found for uranium were 0·0571 and 0·0569, but the specimens were found to contain impurities. The atomic heats which these values give are, Pd. 5·83, Cr. 6·34, V. 5·9, Wo. 6·17. J. B. H.

624. *Specific Heat of Steam at Constant Pressure.* **O. Tumlirz.** (Wien. Akad. Sitzber. 106. pp. 654–667, 1897.)—The author calculates the specific heat of steam at constant pressure from the results of experiments performed in 1866 by Hirn and Cazin on the expansion of superheated steam. The thermodynamics of the question is given in full, and the use of Hirn and Cazin's results for deducing the specific heat is also justified. The results show that the specific heat of steam at constant pressure has, from the saturation-point to that adiabatic which meets the saturation-curve in the point $\theta=100^\circ$ C., $p=1$ atmosphere, for every pressure the same mean value. This constant value is 0·5256.

J. B. H.

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625. *Equilibrium of Three-Component Solutions.* **B. Kuriloff.** (Zeitschr. phys. Chem. 24. pp. 441–467, 1897.)—The two special difficulties that beset this study, viz., the usually high fusing-points of some of the components and the simultaneous occurrence of many solid phases, are absent from the system picric acid, β-naphthol, and benzol, in which the solubility-curves show that only binary solid phases, benzol picrate, and β-naphthol picrate, occur in addition to the components themselves. Denoting these five substances, one or more of which, as solid phases, may with the solution and vapour constitute the system in equilibrium, by P, N, B, BP, NP respectively and plotting the isothermals for 135°, 120°, 100°, 29°·5 on a triangular diagram after Roozeboom's manner, the author obtains the following results. For temperatures between 157° (the fusing-point of NP) and 116° the isothermals are continuous curves beginning and ending on the PN-axis, and NP is the only solid phase present except at 116°, when there is no B in the system, in which case N too is present; this condition corresponds to some point q towards the N-end of the PN-axis. From 116° to 111° the isothermals are made up of a stretch er starting on the PN-axis with NP as sole solid phase, and a stretch rs ending on the BN-axis with N as solid phase, the two solid phases occurring together at r; at 111°, however, when there is no B in the system there is also solid P as well as NP, this condition corresponding to some point d towards the P-end of the PN-axis. For temperatures from 111° to 84°·3 (the fusing-point of BP) each isothermal starts from the BP-axis and ends on the BN-axis, and is made up of stretches gf, fl, lm with P, NP, N respectively as solid phases, P and NP occurring together at f, and N and NP at l: further, at p, where the 84°·3 isothermal cuts the PB-axis, the solid phase BP also occurs with P. Between 84°·3 and 78°·5 the isothermals start from the PB-axis and have stretches tu, uv, vw, wx, with BP, P, NP, N respectively as solid phases, two neighbouring solid phases occurring at the junctions u, v, w, but on the isothermal for 78°·5 the points u and v coalesce into one o, which is a quintuple point, since three solid phases are there present with the solution and vapour. For temperatures between 78°·5 and the neighbourhood of 4° three-stretch isothermals $ijyz$

again occur, but with BP replacing P in the first stretch as solid phase. In the neighbourhood of 4° B begins to appear as solid phase, and two quintuple points k, k' must occur with BP, B, NP and N, B, BP as coexisting solid phases; but this part of the author's diagram is constructed from Schreinemakers' theory and not from experiment. Thus a line dfo is the locus of coexisting P and NP solid phases, ok of BP and NP, qk' of N and NP, oup of P and BP, and there will similarly be lines ka, kck', $k'b$ for the pairs BP and B, NP and B, N and B. The points k, k' are by theory positions of minimum temperature. R. E. B.

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626. *Equilibrium in Three-Component Systems.* III. **F. A. H. Schreinemakers.** (Zeitschr. phys. Chem. 25. pp. 305–331, 1898.)—In a former memoir the equilibrium of such systems, in which two liquid phases, but only a single solid phase (and that one of the components), can occur, was considered; the extended case in which two solid phases, each being a component, may occur, is now investigated, but the results are too intricate for an abstract. The influence of foreign bodies on the transition-temperature of a solid substance in a liquid, *i. e.*, the temperature at which the solid phase of a substance A appears with two solutions, of which one contains more A than B, and the other more B than A, is next considered both experimentally and theoretically, and it is shown that the transition-temperature is raised or lowered by the addition of a third component according as it is the less or the more concentrated solution of the solid in which this third component is the more soluble. R. E. B.

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627. *Internal Virial of an Elastic Body.* **J. Finger.** (Wien. Akad. Sitzber. 106. pp. 722–738, 1897.)—It is shown that the internal virial per unit volume is $-\frac{1}{2}(X_x+Y_y+Z_z)$, where X_x is the x-component of stress on a plane normal to the x-axis, &c. It is also expressible in terms of the elastic potential; but for details the paper must itself be referred to. R. E. B.

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628. *Characteristic Equation of Liquids.* **M. Thiesen.** (Annal. Phys. Chem. 63. 1. pp. 329–335, 1897.)—Four different hypotheses are examined, viz., that the intrinsic energy is of the form

$$(1)\ V_1+V_2t,\quad (2)\ V_3+V_4p,\quad (3)\ T_1-pv,\quad (4)\ T_2v^{-1}+\beta pv,$$

for each of which some theoretical reason may be assigned, V and T representing functions of v and t respectively. These give for the isometric specific heat expressions of the forms

$$(1)\ V_5,\quad (2)\ F_1(tV_6),\quad (3)\ T_3-F_2(tv^{-1})\equiv T_3+P,$$
$$(4)\ F_3(tv^{-\beta})+v^{-1}T_4,$$

where F denotes a function and P a function of p. None of these is true for water, and therefore cannot be general. R. E. B.

SOUND.

629. *New Theory of Hearing.* **Hurst.** (Journ. Phys. Chim. Élem. 141. pp. 50–54, 1898.)—The experiments of Kohlrausch and others have established that two waves separated by a suitable interval of time suffice to give the sensation of a note whose pitch is determined by the ear with a certain degree of approximation: the limits of possible error being expressed by the ratio 24/25. When the absolute number of vibrations succeeding each other at the same interval of time goes on increasing up to 16 vibrations, beyond this the precision attained does not vary. These results condemn all the theories founded on "resonance," which attribute the sensation of pitch to the vibration of fibres of the basilar membrane which would answer to the note to which each of them is tuned. The theory proposed by the author explains quite otherwise the correspondence between a given note and a given group of the fibres of the organ of Corti. The main point in the theory is the following:—A single wave sets in motion successively all the fibres respectively of the basilar membrane and the membrane of Reissner: but the motion of these membranes imparts only a motion on the whole to the organ of Corti which they comprise between them, and does not affect the nervous fibres of that organ. As disturbances succeed each other, the direct wave which is transmitted by the basilar membrane crosses the return wave which comes back by the membrane of Reissner; at the point of crossing, the two membranes are sharply caused to approach, and the organ comprised between them is compressed: this compression affects the nervous fibres at the point of crossing. The author endeavours to show that the function of the middle ear is to reinforce low notes and to extinguish relatively high notes. He develops a theory of concord and discord, and replies to objections which may apparently arise from certain pathological observations as to the seat and result of internal lesions. J. J. S.

ELECTRICITY.

630. *Irreversible Wave Motions.* **L. Boltzmann.** (Berlin. Akad. Sitzber. 44. pp. 1016–1018, 1897.)—Planck, in his papers on irreversible wave-motions ('Strahlungsvorgänge'), Berlin. Sitzungsberichte, Feb. 4, 1897, etc. [see Phys. Soc. Abstracts, No. 651, 1897], conceives a space bounded by an absolute reflecting surface. A system of electromagnetic waves is set up in this space according to Maxwell's equations, it being assumed that there is no dissipation of energy. If there be introduced into the space small resonators, Planck maintains that the wave system will be altered in an irreversible manner, and that without dissipation of energy. Boltzmann asserted (June 17, 1897) that if at any instant the magnetic polarisations were reversed, the electric forces and polarisations remaining unchanged, the system of waves must retrace its course, and is in that sense reversible. Planck replied (July 8, 1897) that this reversed motion is inconsistent with his assumed fundamental condition, namely, that the primary wave in the neighbourhood of any resonator is to possess at all times finite and continuous values. Granted, then, that the reversed motion would take place, it does not, he says, contradict his theory. Further, Planck asserted that there is no other case in nature in which irreversible processes take place without dissipation of energy. In the present paper Boltzmann asserts :—

(1) The surface of a resonator may be regarded as part of the bounding absolutely reflecting surface, and can no more give rise to an irreversible process than the bounding surface itself can.

(2) If resonators render irreversible processes possible, then Poincaré's view must be wrong, that irreversible processes cannot be deduced theoretically from the differential equations of pure dynamics.

(3) In the theory of gases there exists a state, or distribution of momenta, more probable than any other (the state in which H is minimum), and a system generally tends to pass into that state; but the reverse motion, in which it would pass out of the state, is mathematically possible, though highly improbable. So in a system of waves there may exist a state more probable than any other. And, precisely as in the theory of gases, the system tends to pass into that state, but the reverse motion is mathematically possible, though highly improbable. The most probable state is called by Boltzmann 'ungeordnet.' The states to which we should apply the term ungeordnet are infinite in number compared with the states to which we should apply the term geordnet. The chance, therefore, that the system being now geordnet shall become after time t ungeordnet, is infinitely greater than the chance that being now ungeordnet it shall after time t be geordnet, although the course by which it passes from a particular geordnet state x to a particular ungeordnet state y may be described in the reverse way from y to x. In that sense the process is irreversible.

S. H. B.

631. *Irreversible Radiation Phenomena.* **M. Planck.** (Berlin. Akad. Sitzber. 52. pp. 1122–1145, 1897.)—In this (which is the third communication by the same author) is considered a space bounded by a perfectly reflecting spherical surface. In this space is set up a system of electromagnetic waves proceeding radially according to Maxwell's equations. In Parts I. and II. the motion is investigated when the sphere is empty.

In Part III. it is investigated when a small resonator is placed at the centre. Let $\phi(t)$ denote the value of any function at time t and distance r from the centre due to the wave-motion when there is no resonator, and let T be the periodic time. Let $f(t)$ denote the same thing for the waves induced by the resonator, then it is found that $\phi(t)+f(t)=\phi(t+\mathrm{T})$. The question is then discussed, what will happen if the magnetic forces be reversed without change of the electric forces. Will the system exactly retrace its course or not? It is found that the above equation

$$\phi(t)+f(t)=\phi(t+\mathrm{T})$$

is not satisfied in the reverse motion. Whence it is concluded that the motion is irreversible, notwithstanding that there is no dissipation of energy or evolution of heat. It is assumed that the components of force due to the spherical wave which excites the resonator are at all points finite and continuous. It is assumed also that certain special cases are excluded.

For previous papers, see Phys. Soc. Abstracts, No. 651, 1897.

S. H. B.

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632. *Lorenz's Theory.* **Lienard.** (Écl. Électr. 14. pp. 417–424 & pp. 456–461, 1898.)—In the first paper M. Liénard shows how certain of Lorenz's results may be obtained by an independent method, including equation 124 of Lorenz's book and with slight modifications equations 145 and 146.

Let $\alpha\ \beta\ \gamma$ denote components of magnetic force;

$f\ g\ h$ „ „ displacement in ether;

$\mathrm{M}_x\ \mathrm{M}_y\ \mathrm{M}_z$ „ „ dielectric polarisation.

We have six fundamental equations among these nine quantities. To obtain three more we must make some new hypothesis. Now for a body at rest and in electric equilibrium we have, X Y Z being components of electric force,

$$\mathrm{X}=4\pi\mathrm{V}^2f, \text{ etc.}$$

The assumption which, according to Liénard, constitutes the strength of Lorenz's theory is that for a medium in motion these equations do not hold. They must be replaced by

$$X=4\pi V^2 f+\gamma\eta-\beta\zeta,$$
$$Y=4\pi V^2 g+\alpha\zeta-\gamma\xi,$$
$$Z=4\pi V^2 h+\beta\xi-\alpha\eta;$$

$\xi\ \eta\ \zeta$ being components of the convection current.

From which equations are deduced results corresponding to those of Lorenz, as also certain results due to Fresnel and Fizeau.

The question investigated in the second paper is how far Lorenz's theory satisfies the two conditions (1) equality of action and reaction; (2) conservation of energy. $F_x\ F_y\ F_z$ denote ponderomotive component forces on a particle charged with electricity, and $\xi\ \eta\ \zeta$ components of convection current.

I. Considering the equality of action and reaction, we have, $d\omega$ being an element of volume,

$$F_x=\int\frac{\partial}{\partial t}(\beta h-\gamma g)d\omega=\frac{\partial}{\partial t}\int(\beta h-\gamma g)d\omega;$$

where $\frac{\partial}{\partial t}$ denotes change with the time at point fixed in space. Now the condition requires that $\int F_x d\omega=0$, which is not generally satisfied in the above equation. That is because it is assumed that force takes time in its propagation through space, and therefore action and reaction referred to the same instant cannot generally be equal and opposite. It is sufficient to satisfy the principle if on average of time $\int F_x d\omega=0$—and that is satisfied. It is concluded then that Lorenz's theory does satisfy the principle in the only way in which it can be satisfied. M. Liénard holds that in Hertz's theory it is not satisfied.

II. *Conservation of energy.*—In this case we get

$$V^2\Sigma\frac{\partial}{\partial x}(\beta h-\gamma g)d\omega dt=$$
$$\left(4\pi V^2\Sigma f+\frac{\partial f}{\partial t}+\frac{1}{4\pi}\Sigma\alpha\frac{d\alpha}{dt}\right)d\omega dt+\Sigma 4\pi V^2\overline{\rho-S}\xi d\omega dt$$
$$+\Sigma 4\pi V^2 f(u+u_1)d\omega dt,$$

where Σ denotes summation for all particles within $d\omega$, S is the apparent electrification or "charge fictive," u the velocity in x of the medium, u_1 that of a particle relative to the medium. The left-hand member is, according to Poynting's theory, the vector-flow of energy in x. To verify the principle, it is shown that the second member represents the increase of energy within the element $d\omega$ plus the heat evolved plus the work done. It is further shown that the Lorenz theory also explains Faraday's phenomenon.

S. H. B.

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633. *Contact Electricity.* **Pellat** and **Sacerdote.** (Journ. de Physique, 7. pp. 24–28, 1898.)—Suppose a plane condenser formed of two plates of different metals MM′ joined by a metallic

wire mm', and the whole placed in a vacuum. On account of the difference of potential v at contact, the armatures have charges:

$$\pm q = \pm \frac{S}{4\pi e} v,$$

S being the area of the plates, and e their distance apart.

Cause the distance e to increase and decrease periodically within limits so small that they always remain infinitely small compared with the dimensions of the armatures. To these periodical variations of capacity will correspond in the wire alternating currents, and hence disengagement of heat by the Joule effect. The authors set out to prove that this energy set free is integrally equivalent to the work expended to produce these variations of capacity, contact need not be brought in to furnish the energy, and hence it is useless to imagine chemical actions as produced at the contact of the two metals, or of these latter with the dielectric.

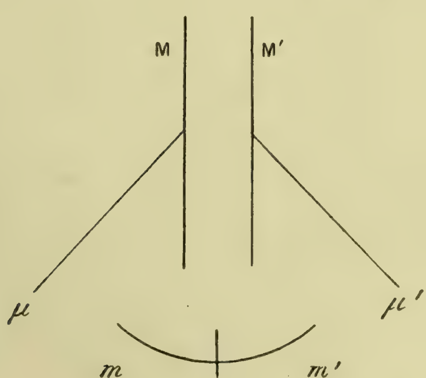
Let the condenser be caused to describe the following closed cycle, the electric attractions being supposed constantly compensated by forces exterior to the system, and the work of these latter being considered :—

1. Let the wires be cut somewhere at $\mu\,\mu'$ and the plates separated to the distance $e+\Delta e$. The work to be supplied in this case is:

$$T_1 = 2\pi\sigma^2 S\Delta e = 2\pi \frac{q^2}{S}\Delta e = \frac{Sv^2}{8\pi e^2}\Delta e,$$

where σ is the surface-density; the charges have remained constant $\pm q$, and the difference of potential of the armatures has become

$$v+\Delta v = v\frac{e+\Delta e}{e}, \quad \text{or} \quad \Delta v = v\frac{\Delta e}{e}.$$



2. Re-establish communication at $\mu\mu'$. A partial discharge is produced which brings back the difference of potential from $v+\Delta v$

to v, whence, according to the Joule effect disengagement of heat, W_1 (in mechanical units) given by

$$W_1=\int ri^2dt,$$

where r is resistance of connecting thread, and i the value of current at time t. But if L is the coefficient of self-induction of the wire, and V the potential difference at the time t, then

$$L\frac{di}{dt}+ri=V-v,$$

whence, on multiplying the two sides by idt, which

$$=-\frac{SdV}{4\pi(e+\Delta e)},$$

and integrating for the whole duration of the discharge noting that $\int Lidi=0$, we have

$$\int ri^2dt=-\int_{v+\Delta v}^{v}(V-v)\frac{SdV}{4\pi(e+\Delta e)},$$

whence

$$W_1=\frac{S(\Delta v)^2}{8\pi(e+\Delta e)}=\frac{Sv^2}{8\pi(e+\Delta e)}\left(\frac{\Delta e}{e}\right)^2,$$

there remains on the plate the charges

$$\frac{\pm Sv}{4\pi(e+\Delta e)}=\pm q\frac{e}{e+\Delta e}.$$

3. Break the communications $\mu\mu'$ and cause the plates to approach to the distance e. The corresponding work, calculated as in the first operation, is

$$T_2=\frac{Sv^2}{8\pi(e+\Delta e)^2}\Delta e;$$

during this movement by the armatures their difference of potential has descended from v to $v\frac{e}{e+\Delta e}$.

4. Re-establish the communication $\mu\mu'$. The condenser becomes recharged till the potential difference of the plates is again v. Let W_2 be the heat-energy set free during this time in the circuit (the Joule effect); this is expressed according to the above reasoning by

$$W_2=-\int_{v\frac{e}{e+\Delta e}}^{v}(V-v)\frac{S}{4\pi e}dV$$

$$=\frac{Sv^2}{8\pi e}\left[1-\frac{e}{e+\Delta e}\right]^2;$$

the system has returned to its initial state.

The total work supplied $T=T_1+T_2$

$$=\frac{Sv^2}{8\pi e^2}\Delta e\left[1-\left(\frac{e}{e+\Delta e}\right)^2\right]=\frac{Sv^2\Delta e^2(2e+\Delta e)}{8\pi e^2(e+\Delta e)^2}.$$

The heat energy set free, $W_1=W_1+W_2$

$$=\frac{Sv^2}{8\pi(e+\Delta e)}\left(\frac{\Delta e}{e}\right)^2+\frac{Sv^2}{8\pi e}\left[1-\frac{e}{e+\Delta e}\right]^2$$

$$=\frac{Sv^2\Delta e^2(2e+\Delta e)}{8\pi e^2(e+\Delta e)^2}.$$

Whence $T=W$.

The total energy set free in virtue of the Peltier effect by the two currents in opposite directions is zero, since quantities of electricity equal and of opposite sign have passed.—It is to be noted that in the system considered, consisting of two plates MM′, each furnished with a wire *mm′*, and first of all non-electrified, *at the moment of making contact at mm′ the phenomenon of the charge of the condenser is accompanied by a diminution of the energy of the system*; a diminution equivalent to the heat set free according to the Joule effect, the Peltier effect being negligible in comparison. Hence it follows that in an electrified system when the metals which constitute it are not of the same nature, there may be less energy, all the other conditions remaining the same, than when it is not electrified. The expression $\frac{1}{2}\Sigma QV$ for representing the increase of energy acquired by a system on charging is not rigorously exact except in the case in which the metals are of the same nature. J. J. S.

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634. *Rotations in Uniform Electrical Fields.* **E. R. von Schweidler.** (Wien. Akad. Sitzber. 106. pp. 526–532, 1897.)—In 1881 Hertz treated the case of a conducting sphere rotating uniformly about a diameter at right angles to the direction of an electric field in which it was placed. Heydweiller has recently pointed out that in order to generalise this problem it is necessary to consider the opposite case of a dielectric sphere revolving in a conducting liquid. This was done, and led to the conclusion that the couple due to the electric forces acts in the sense of the rotation, instead of against it as in Hertz's case. For the qualitative agreement of this result with Quincke's experiments (Wied. Ann. 59. p. 417, 1896) Heydweiller was led to infer that a great part of the effects observed might be due to this couple.

The present author then proceeds to discuss the general case mathematically, the conductivity of both sphere and surrounding medium being at the outset treated as finite. The chief results of the analysis may be stated thus:—(1) The couple due to the rotation in the electric field is positive (in the direction of the rotation) if the conductivity in the outside medium exceeds that of the sphere, and the couple is negative when the order of the

conductivities is reversed. (2) If the sphere is non-conducting the couple reaches a maximum for the angular velocity given by $c\tau = 3/4$, where c is the conductivity of the medium in electrostatic units, and τ the period of rotation of the sphere. Thus to get the maximum effects the values of τ are of the following order:—in mercury 10^{-16} sec., in alcohol 2×10^{-6} sec., in benzole 20 sec., and in vaseline oil 200 sec. The couples may reach the value 10 dyne-cm. in favourable cases.

The author has also endeavoured to measure experimentally the couples thus called into play. In the case of rotations in ether, the values were small in comparison with those due to the torsion of the suspension and the viscosity of the liquid. In other cases, as crown glass in benzole, and a large sphere of quartz in carbon disulphide, the values were of the same order of magnitude. While admitting he has not given a complete theory of Quincke's experiments, the author feels that the couples referred to play a significant part in the phenomena in question. E. H. B.

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635. *Dielectric Constants of Liquid Mixtures.* **J. C. Philip.** (Zeitschr. phys. Chem. 24. pp. 18–38, 1897.)—The dielectric constants are measured by means of Nernst's method slightly modified. Arms 1 and 2 of the Wheatstone bridge contain equal electrolytic resistances of small capacity; arms 3 and 4 each contain an electrolytic resistance, a condenser consisting of two brass plates separated by a glass or ebonite plate, by moving which the capacity may be altered to a known extent, and finally a condenser in which the dielectric is the liquid under examination. The two condensers containing liquid are first filled with the same substance; a small quantity of a second substance being added to one of them, balance is disturbed, and to restore it the ebonite plate in the proper air-condenser must be moved so that the change of capacity is equal to that produced in the liquid. In this way the difference between the dielectric constant of the solution and of the pure solvent is obtained with considerable accuracy.

The calculation of the dielectric constants of the mixtures from those of the components is carried out by the formulæ which apply to the refractive index, viz.:—$100\,C = p_1 C_1 + (100 - p_1) C_2$, where C, C_1, and C_2 apply to the mixture and the two components respectively, and p_1 is the percentage of the first component in the mixture. Calling k and d the dielectric constant and density, $C = \sqrt{k} - 1/d$ or $k - 1/(k+2)d$. The first expression gives results very much nearer the truth than the second, though neither is entirely satisfactory. Some mixtures give entirely abnormal results; for example, mixtures of ether and chloroform, most of which have a dielectric constant greater than 5, whilst the dielectric constants of ether and chloroform are 4·3 and 4·8 respectively.

By means of the $\sqrt{k}$ formula the author calculates the dielectric constants of various alcohols from the dielectric constants of their solutions in benzene and toluene. In all cases the dielectric con-

stants decrease as the solutions become more dilute, and appear to tend towards limiting values which are very considerably smaller than those found for the pure substances. The author connects this change in the dielectric constant with the breaking up of the complex aggregates of alcohol molecules which exist in more concentrated solutions and in the pure substances. Nitrobenzene, the molecules of which show little tendency to form aggregates, gives a dielectric constant which is not affected by dilution. T. E.

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636. *Free Electricity in Geissler Tubes.* **E. Riecke.** (Annal. Phys. Chem. 63. 1. pp. 220–229, 1897.)—The researches of Hittorf on the potentials of points situated on the axis of a Geissler tube filled with nitrogen, and those of Warburg on the fall of potential in the neighbourhood of the kathode, furnish data for the calculation of the volume and surface densities of the charges at various points in the tube. The author has performed this calculation, and gives the results of it in the present paper. The quantities calculated include the surface-densities on anode and kathode and at the boundary of the dark space, the volume-densities at specified distances from the anode, and the electric force at the same distances from the anode; each is calculated for three different strengths of current and for pressures of 0·2 and 0·6 mm. mercury respectively. The results show that the surface- and volume-densities and field-strengths on the anode side of the dark space, and at the boundary of the dark space itself, are independent of the current; alteration of current affects only the kathode. On the other hand, alteration of pressure affects the anode side only, the distribution of electricity round the kathode being the same for a given current whether the pressure is 0·2 or 0·6 mm.

In the second part of the paper the author assumes that electric conduction in gases is due to the convection of electricity by a relatively small number of positive and negative ions mixed with a larger number of unelectrified molecules; the electric density at any point will depend on the difference between the number of positive and negative ions per cubic centimetre at the point. The interval between two collisions of the molecules of such a gas comes out much smaller than if the gas contained no ions. J. L. H.

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637. *Structure of Kathode Light.* **E. Goldstein.** (Berlin. Akad. Sitzber. 40. pp. 905–914, 1897.)—The author has previously shown that the kathode light of induced discharges consists of three distinct kinds of radiation, corresponding to the three layers round the kathode. The first layer nearest the kathode, and the second one are composed of rays emitted in straight lines from the kathode, which penetrate through the third layer. Solid bodies placed in the second layer cast shadows, of which the umbra is filled with light similar to that of the third

layer, whereas bodies immersed entirely in the radiation of the third layer cast no shadow. For brevity, the rays of the second and third layers are referred to as K_2 rays and K_3 rays respectively. Several experiments with tubes of various shapes are described, which show that the K_3 rays are emitted in all directions from every point reached by K_2 rays, and proceed from their origin in straight lines. The rays found in the umbra of bodies screening-off the K_2 rays proceed from points illuminated by K_2 rays which have passed the edge of the screen; if the screen is large enough to cut off all the K_2 rays, its umbra is almost completely dark. Both K_2 and K_3 rays are deflected by a magnet. When K_2 rays impinge on a solid, diffused rays are emitted in all directions, the reflected radiation being most conspicuous, because the transmitted rays are absorbed by the solid, unless its thickness is small. The author supposes that gas molecules behave like solids to these rays, so that kathode rays reflected from the walls of a vacuum-tube and Lenard rays transmitted through the walls are of similar nature, both being K_3 rays. It is, however, open to question whether the radiation resulting from the impact of K_2 rays is of the same kind as the K_2 rays themselves; their colour is usually different, although they are similarly deflected by a magnetic field. J. L. H.

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638. *Interference and Electrostatic Deflection of Kathode Rays.* **G. Jaumann.** (Wien. Akad. Sitzber. 106. pp. 533–550, 1897.)—Several experimenters having been unable to repeat successfully the author's experiments on the interference of the blue kathode light, he describes the details of them more fully. Two parallel rectangular aluminium plates, 10 cm. long, 4 cm. wide, and 2 cm. apart, are connected by a loop of brass wire, 250 cm. long and 0·8 mm. in diameter; a movable binding-screw serves to connect the wire with the negative pole of an influence-machine, and the whole is placed under a receiver which can be exhausted. The wire leading to the influence-machine contains a spark-gap; the anode in the receiver is far removed from the kathode plates, and all contacts must be good. With these precautions, the interference-surface between the parallel kathodes is seen as a clear blue plane of light, surrounded by a pale bluish mantle; the rest of the space between the plates is nearly dark. Displacement of the movable contact along the wire causes a shift of the light towards one or other of the kathode plates, and its edges curve over towards the nearer plate. The author is of opinion that the kathodes do not exert a deflecting action upon the kathode rays, as Goldstein supposes, but that the deflection observed by Goldstein is partly due to interference and partly to electrostatic deflection of the rays. Experiments are described which seem to show that the interference-surfaces for the intense radiation from two kathodes, inclined to each other at an angle, are very similar to those obtained by Mach in the case of sound-waves of great

amplitude: this supports the view of the author that kathode rays are longitudinal ether-waves.

Referring to the experiments of Wiedemann and Schmidt on the displacement of the point of origin of kathode rays by an electrostatic field, the author gives evidence that the rays themselves are deflected after leaving the kathode, in addition to the displacement of their origin. He shows that this is in accord with the longitudinal-wave theory, since a purely longitudinal disturbance can only be propagated along the lines of maximum and minimum electrostatic force; in any other direction transverse waves would accompany it. Finally, experiments are described which show that in certain cases the kathode rays follow the direction of the maximum electrostatic force and do not always proceed in straight lines.

J. L. H.

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639. *Electric and Magnetic Oscillation in Hertz Waves.* **K. Waitz.** (Annal. Phys. Chem. 63. 1. pp. 234–241, 1897.)—The object of the investigation is to show that the electric and magnetic waves possess different damping coefficients when passing through the same conductor. The conductors examined range in conductivity between copper and acetic acid, and the method of measuring the absorption is by constructing resonators in the form of a rectangular circuit. For solids a wire of the material is bent into rectangular shape, and for liquids a glass tube of similar form is used, the ends being connected to an electrometer, as in the experiments of V. Bjerknes. The waves from an oscillator, consisting of two cylinders sparking into each other, are allowed to fall on a slit or grating formed by zinc plates, which allow either the electric or the magnetic wave to pass through, according to its position; the wave is then received on the resonator and absorbed, the amount of absorption being measured by the first swing of the electrometer-needle. In the case of metals the damping is the same for electric and magnetic waves, and corresponds with the values given by Bjerknes. The electric oscillation has a damping-coefficient increasing with decrease of conductivity of the material; the absorption of the magnetic oscillation, on the other hand, first increases and afterwards decreases again as the resistance is increased. Its value is a maximum for a specific conductivity of approximately 20×10^{-8}. The anomalous electric dispersion and absorption of glycerine, amyl alcohol, ethyl alcohol, and acetic acid have previously been investigated by Drude (see Phys. Soc. Abstracts, No. 444, 1896.) J. L. H.

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640. *Coherers.* **C. Rovelli.** (Elettricità, Milan, 17. pp. 36–37, 1898.)—The author uses a coherer made up of iron filings, with two thin wire contacts. It is only found necessary to touch the wires or even to blow upon them, in order to restore the needle to its position; it is not necessary to shake the iron filings. The inference is that the change in the filings is confined to the

immediate neighbourhood of the wires; and the author thinks the action of the electric wave produces an increase in the difference of potential at the ends of the wires immersed in the iron filings. The necessity for this latter conclusion is questioned by R. Malagoli (Elettricità, Milan, 17. pp. 102–103, 1898). A. D.

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641. *Blindness from the Electric Arc.* **A. J. Rowland.** (Amer. Electn. 10. pp. 107–108, 1898.)—The author describes the well-known symptoms of inflammation of the conjunctiva, or outer membrane covering the front of the eyeball, due to looking at arcs taking large currents without proper guards for the eyes. The author recommends, in cases of a slight attack, either of the following eyewashes:—Six grains of borax in a fluid ounce of infusion of sassafras-pith, or ten grains of boric acid in an ounce of camphor-water. In a very bad case a *physician* should apply cocaine. In protecting the eyes against the burning power of arcs taking large currents, it is not sufficient to wear such glasses as are made for those who repair and adjust common arc lights; far too much light gets round them. It is necessary to use a mask covering the whole face. E. C. R.

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642. *Surface Travel on Electrolytes.* **W. E. Fiske** and **W. D. Collins.** (Amer. Jour. Sci. 5. pp. 59–62, 1898.)—The electrolyte, a saturated solution of copper sulphate, was contained in a tank a metre long and a square decimetre in section. The electrodes were of sheet copper, equal in area to the section of the tank. The distance between them could be altered so as to give a column of variable resistance. The first process was to measure the resistance of the solution by Kohlrausch's method. Next, with the solution in series with a spark-gap, a photograph of the spark was taken and the number of half-oscillations corresponding to the length in question was plotted against its ohmic resistance. This was done for lengths of solution of resistance from 6 to 24 ohms. Manganin wires of different lengths were then put in the place of the electrolyte, and the operations repeated. The curves thus obtained were compared. The wires showed no surface-travel. An examination of the diagrams of the most reliable results shows that the points on the solution-curves unquestionably tend to fall below those on the wire-curves. The evidence is in favour of a surface-travel in the electrolyte. The investigation is to be continued, using an apparatus giving a higher period. S. S.

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643. *Polarisation in Alcoholic Solutions.* **E. Haschek.** (Wien. Akad. Sitzber. 106. pp. 580–589, 1897.)—The alcohol used was 99·7 %; had specific gravity at 17° C. of 0·7945, and conductivity

39×10^{-11}. On account of the high resistance of the solutions, the E.M.F. of polarisation increases slowly. The maximum of polarisation is higher for alcoholic solutions than for the corresponding water solutions. The polarisation falls with increase of temperature in alcoholic solutions, as it does in aqueous solutions. In the neighbourhood of the boiling-point the fall is exceptionally rapid for salt solutions. With rising concentration the polarisation falls, and more rapidly than the concentration increases. S. S.

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644. *Action of Drop-Electrodes.* **W. Palmaer.** (Zeitschr. Phys. Chem. 25. pp. 265–283, 1898.)—Two tubes containing 1/10 saturated HgCl are connected vertically by a narrow tube, and mercury allowed to drop from a capillary point in the upper tube, through the connecting tube, into a reservoir of mercury in the lower. The calomel is found to be abstracted from the solution in the upper tube and restored to that in the lower, where the drops unite with the reservoir. The concentrations are too small to allow of this being demonstrated by chemical means; but the variation is shown by parasitic electrodes of mercury, which become negative in the upper and positive in the lower tube when the dropping takes place. This verifies Nernst's theory of the mode of action of drop-electrodes, that the mercury ions are deposited on the expanding drop, carry the chlorine ions in the double-layer down with the drop, and reunite with them when the drop is lost in the surface of the reservoir. Quantitative results show that the concentration-change proceeds to a high degree, but is limited by the unavoidable mixture caused by the drops falling through the connecting tube.
B. B. T.

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645. *Electrocapillary Phenomena.* **H. Luggin.** (Zeitschr. Elektrochem. 4. pp. 283–289, 1897.)—A lecture expounding the leading facts, and the theories of Lippmann, Helmholtz, and Nernst, with description of various lecture experiments. B. B. T.

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646. *Sullivan Galvanometer.* (Elect. Rev. 42. pp. 592–593, 1898.)—The paper gives an account of trials made on a Sullivan galvanometer when subjected to excessive vibration on a torpedo-boat. The galvanometer was placed on a pad of hair-felt $1\frac{1}{2}$ inch thick in a tray somewhat larger than the galvanometer-base. At each corner of the galvanometer-base and of the tray were fixed screws, and between the pairs at each corner were stretched india-rubber bands, forming an elastic stay sufficient to keep the galvanometer in position. Under the worst conditions of vibration, with the galvanometer immediately over the propeller and on open circuit, the spot of light remained quite steady, except for occasional throws of 5 divisions, increasing at intervals up to

20 divisions. An ordinary marine galvanometer under the same conditions vibrated to such an extent that the spot continually left the scale, rendering any measurements impossible. G. H. Ba.

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647. *Permanence of Manganin Resistances.* **W. Jaeger** and **St. Lindeck.** (Zeitschr. Instrumentenk. 18. pp. 97–106, 1898.) —In the course of the experimental work upon standards of resistance at the Reichsanstalt since 1891, comparisons have from time to time been made between the mercury standard and manganin coils. The results are presented in the form of tables. It now appears that manganin copies of the standard ohm may have even greater constancy than mercury copies. Special precautions have been taken in the design, manufacture, and protection of the manganin resistances to attain this result (see Wissensch. Abhandl. of the Reichsanstalt, Vol. 2). The observed change in a manganin ohm, during the whole period, in no case exceeds a few hundred-thousandths of an ohm. Incidentally, a coil of "patent nickel" is included in the tables; this alloy appears to have the same order of constancy as that of manganin. [For "patent nickel," see Elect. Rev. 42. p. 536 *et seq.*, 1898.] Mercury resistances *diminish* in resistance with time; in five or six years this diminution may amount to about a ten-thousandth of the nominal value of the resistance of the whole mercury column. With manganin the tendency is for the resistance to *increase*; the greatest change observed in a one-ohm coil is 55 millionths of the total resistance, in $5\frac{1}{2}$ years.

The second part of this investigation relates to tests of the constancy of manganin resistances of fractional parts of an ohm, such as are used in practice for current tests on electric-light and power circuits. The greatest variation occurred in a wire of 0·1 ohm: the change is a little more than 0·01 per cent. in $2\frac{1}{2}$ years. Details as to soldering and varnishing are not given.

Lastly, the authors describe the tests made on manganin coils of high resistance. It is here that finer wires have to be used; these are necessarily harder than those of greater gauge, for they cannot be annealed, and are therefore drawn cold [see Elect. Rev. *l. c.*]. The consequence is a very decided variation of resistance with time: a coil that was 10003·13 ohms in February 1895 fell to 10002·91 by the following June; it increased to 10004·14 by February 1896, and fell again to 10003·78 in January of the present year. The extreme limits of variation for coils of manganin, of the nominal values specified, are stated to be as follows:—

Nominal Value.	Variation per cent.
From 1–10 ohms	0·01
„ 100–1000 „ or from 0·1 –0·01 ohm	0·015
„ 1000–10000 „ „ 0·01 –0·001 „	0·02
From 0·001–0·0001 „	0·03

Corresponding to a particular variation, the table shows two ranges of values of resistance, a higher and a lower. The best range is between 1 and 10 ohms; the higher range introduces the imperfectly annealed manganin; the lower range is probably affected by solderings or end-contacts. R. A.

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648. *Capacity of Coiled Cables.* **A. Dearlove.** (Electrician, 40. pp. 783–784, 1898.)—The simplest method for measuring capacity is by comparison of so-called "direct deflections." But in the case of a cable whose length exceeds a few n.ms., this method is generally regarded as inapplicable, especially if the cable is coiled—the usual condition in the factory and on board ship. It is well known that the device of connecting the two ends of the coiled cable directly together, and charging and discharging at the "double end," gives better results than when testing from only one end. The author points out that the effect of this "double-ending" is (1) to eliminate the effect of the self-induction of the circuit, and (2) to diminish its resistance. Experiments are described from which it is clear that the "true capacity" of a coiled cable of 444 n.ms., 155·4 mfds., is easily to be determined by "direct deflection" when the two ends are available. By "true capacity" the author probably means the capacity calculated by summing the factory-values of each separate 3-n.ms. drum of core from which the cable is constructed. With the 444 n.ms. of cable, the error introduced by the "direct-deflection" method, testing from a single end, is 18·5 per cent. The error, testing from the double end, is practically *nil*. Some useful figures are given illustrating the errors that may be introduced by employing galvanometers of different "decrements." For instance, a cable whose "true capacity" per n.m. was 0·350 appeared to have a capacity of 0·299 when the galvanometer had a period of 0·85 sec., and a capacity of 0·353 when the period of the galvanometer was 3·125. Finally, the author shows the extent of the errors introduced into "direct-deflection" capacity-tests if an ordinary shunt is applied to galvanometers of the d'Arsonval type; the error may easily be 300 per cent. The same test may be made with the "universal" shunt of Ayrton and Mather, to within 1 per cent. R. A.

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649. *Electric Conductivity of Copper.* **S. Sheldon.** (Elect. Rev. 42. pp. 525–526, 1898.)—In order to investigate the relation between annealing and electrical conductivity, a sample of copper was passed several times through a draw-plate until it became very hard. The wire was then cut up and annealed in separate lengths at different temperatures, (1) in a vacuum, (2) in hydrogen, with the results shown in the following table:—

Annealed in a vacuum.		Annealed in hydrogen.	
Annealing Temperature.	Conductivity per cent.	Annealing Temperature.	Conductivity per cent.
° C.		° C.	
20	101·5	20	99·0
37	101·5	45	99·0
54	101·5	105	99·3
118	101·6	234	99·8
215	102·0	360	101·0
300	102·1	483	101·9
600	102·4	1050	89·3
755	102·7		
930	99·0		

R. A.

650. *Resistance of Electrolytes.* **P. C. McIlhiney.** (Indus. and Iron, 24. pp. 245–246, 1898.)—A method is described for measuring the resistance of electrolytes. It is a slight modification of the ordinary potentiometer method. The electrolyte is first connected in series with a known resistance, and the potential difference at the terminals of the known resistance is observed. For the second operation, the electrolyte is replaced by a second known resistance, the first known resistance being still in circuit. The potential difference is again observed at the same points as before. At the terminals of the electrolyte the current is alternated by a rotary reverser, but the current through the known resistances is always direct. This method would probably be useful where approximate and rapid measurements are required to be made with a single galvanometer or voltmeter of direct-current type. R. A.

651. *Platinised Electrodes.* **F. Kohlrausch.** (Annal. Phys. Chem. 60. 2. pp. 315–332, 1897.)—The platinising solution employed by Lummer and Kurlbaum for their bolometers is very useful for coating electrodes for the measurement of electrolytic resistances. It consists of 1 part $PtCl_4$ to 0·008 of lead acetate and 30 of water. It gives by electrolysis a dull, deep, platinum black, and produces a well-defined minimum of tone when used in the telephone method. Even in the case of a normal NaCl solution with only 1·74 ohms resistance and electrodes of 10 sq. cm. surface, the resistance was determined with an error of only 0·5 per cent. The new method of platinising is especially valuable on account of the smaller electrodes which can now be employed.

Even with only 0·5 sq. cm. of surface a useful minimum is obtained for resistances as low as 100 ohms. The minimum is greatly improved by thickening the deposit by further electrolysis, and the error in the determination of 20 ohms may thus be reduced to one or two thousandths. The author describes various forms of such electrodes, either fixed or movable. To insure wetting of the electrodes by water, they should be first treated with a drop of alcohol. The electrodes are more delicate than those previously used, and therefore require careful protection when not in use.

E. E. F.

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652. *Thermopiles.* **H. Rubens.** (Zeitschr. Instrumentenk. 18. pp. 65–69, 1898.)—The Melloni thermopile as generally constructed has the objection of sluggishness and a doubtful zero; it has come to be regarded as incapable of the sensitiveness of the bolometer and the radio-micrometer. By reducing the thermal capacity of the parts, the author has succeeded in making an instrument of extreme sensitiveness. He rejects antimony and bismuth, for mechanical reasons, and uses iron and constantan, both of which can be drawn into fine wires of sufficient strength. The heat-receiving junctions are arranged in a single line, 1 mm. apart. With an instrument formed of 20 couples he obtains 0·00106 volt per 1° C.; the resistance from terminal to terminal is 3·5 ohms. Assuming that his galvanometer-scale can be read to within 0·1 mm., he is able to measure with certainty to one-millionth of 1° C., a sensitiveness that compares very favourably with the instruments of Langley and Boys.

Reference is given to a paper by A. Crova (Compt. Rend. 125. p. 894, 1897), who seems to have been the first to apply an iron-constantan couple to a practical purpose. Iron-constantan gives 53 micro-volts per 1° C., about half the E.M.F. of antimony-bismuth; the advantage is therefore only due to mechanical causes. The linear arrangement of the couples is for convenience in spectrum experiments; the author proposes to use them in the place of cross-wires. Owing to its small thermal capacity, the instrument responds with sufficient rapidity for such measurements.

R. A.

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653. *New Species of Transition-Cell.* **E. Cohen.** (Zeitschr. phys. Chem. 25. pp. 300–304, 1898.)—The author shows from the measurements of Callendar and Barnes (Proc. Royal Soc. 42. p. 117, 1897), that the Latimer-Clark cell is a fourth and simpler form of the transition-elements described by himself, Bredig, and van't Hoff. The E.M.F. is represented by two curves intersecting at 38°·75: the solubility (determined by C. and B.) shows a transition-point at 39°·9. The author finds with the dilatometer 38°·5. From the work of Jaeger (Annal. Phys. Chem. 63. 13. p. 354, 1897) on the E.M.F. with $ZnSO_4 7H_2O$ and $ZnSO_4 6H_2O$ the transition-point is found to be 39°.

B. B. T.

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654. *Clark Cells on Closed Circuit.* **T. Wulf.** (Wien. Akad. Sitzber. 106. pp. 562–579, 1897.)—These measurements have been made on small cells of standard pattern, and not on specially large cells as did Skinner, Phil. Mag. 38. p. 271. The results shortly stated are:—

(1) The internal resistance of the cells (cylindrical glass vessels of 2 cm. diameter, distance of electrodes 3-4 cm.) was at the ordinary temperature between 40 and 80 ohms, varying with the distance and size of the electrodes (active surface of zinc rod 2–3 cm.^{2}).

(2) The internal resistance changed very rapidly with temperature so as to treble itself between 30° and 5° C.

(3) A diminution of internal resistance with the strength and duration of the current could not be stated with accuracy.

(4) Polarisation occurred with strong currents of 0·005 ampere after 0·1 second. It increased only slowly in the first 10 minutes, afterwards more quickly.

(5) After breaking the current the polarisation sank to a small fraction in a few minutes. After repeated short-circuiting through only 50 ohms external resistance for a minute and longer, the E.M.F. of the open element was not permanently affected.

(6) Similarly a cell, circuited for 2 hours with 200 ohms, by which its E.M.F. was reduced to almost half its usual value, after 2 minutes reached its original value to within 0·1 %.

The author measured the E.M.F. of the cells by means of a condenser and ballistic galvanometer. A mechanical key actuated by a falling body was used for contacts of short duration. S. S.

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655. *Thermo-electric Batteries and the Jacques Cell.* **C. J. Reed.** (Amer. Electn. 9. pp. 118–120, 1897.)—Thermo-electric batteries are divided into two classes:—(1) Those which consist of conductors in contact which are incapable of electrolytic decomposition. (2) Those containing electrolytes. The first are well known and of very low efficiency, though permanent. The second have a much higher efficiency, and owing to the chemical action which takes place, and is proportional to the current, they require frequent renewal in the same way as a primary battery. In this second class should be included such cells as the Jacques cell, and the tin-chromic-chloride cell due to W. E. Case. Another cell of the same class results by the immersion of two copper U-tubes in a solution of copper sulphate, one tube being traversed by cold water and the other by steam. Electrolytic oxidation of the carbon in the Jacques cell is due to the current flowing, but is not the source of the energy. No proof has been given that carbon can be oxidised at low temperatures with evolution of energy. W. R. C.

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656. *Oxidation of Carbon without Heat.* **W. E. Case.** (Amer. Electn. 9. pp. 224–225, 1897.)—The author denies the statement of C. J. Reed (see previous Abstract) as to the

oxidation of carbon at low temperatures, by refering to his own experiments, in which he found that carbon is oxidised by chlorine peroxide, and that an E.M.F. as high as half a volt can be so obtained. Processes occurring in nature are also referred to.

W. R. C.

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657. *Thermo-electric Batteries and the Jacques Cell.* **W. A. Anthony.** (Amer. Electn. 9. p. 225, 1897.)—The author objects to the statement of C. J. Reed (see Abstract No. 655) that the Jacques cell is thermo-electric. There is no evidence that a high and a low temperature are required. It is improbable that the continuous application of heat is necessary: the cell only requires to be placed where the temperature is sufficiently high. In order that the thermo-electric theory should stand, it must be shown that a difference of temperature is requisite and that heat disappears when the circuit is closed, or the temperature rises when the circuit is open. The same remarks apply to the tin-chromic-chloride cell. If the latter were normally at the higher temperature it would maintain its action continuously like any other primary cell.

W. R. C.

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658. *Thermo-electric Batteries and the Jacques Cell.* **C. J. Reed.** (Amer. Electn. 9. pp. 266–267, 1897.)—In reply to Case and Anthony (see the two previous Abstracts), the author refers to previous papers (see Phys. Soc. Abstracts, No. 502, 1897) in which he has shown that the voltaic theory is untenable in the case of the Jacques cell. With regard to the tin-chromic-chloride cell, the materials are not renewed in the same way as in a primary cell. In the latter, potential energy is added by placing new materials in position which have more available energy than the old ones; but in the tin-chromic-chloride cell the exhausted materials are renewed simply by cooling, *i. e.* by abstracting more energy: it is not therefore merely voltaic. Case's experiments upon the oxidation of carbon cannot be regarded as at all conclusive as they are wanting in quantitative details. **W. A. Anthony** (Amer. Electn. 9. p. 310, 1897) replies that the Jacques cell may be voltaic because the reactions taking place, viz. the oxidation of carbon and the formation of carbonate from the alkali, are both exothermic. No reduction takes place. It has not been shown that the introduction of cold air is necessary for the working of the cell; probably the action would occur equally well if the air were heated before entering the cell to a temperature higher than that of the bath. With regard to the E.M.F. found when two electrodes of the same metal at different temperatures are immersed in the same electrolyte, there is no reason for saying that it is thermo-electric. The work of C. Liebenow and L. Strasser has shown it to be due to the variation of chemical affinity with temperature. The same work has shown that the air acts simply as a depolariser. **C. J. Reed** (Amer. Electn. 9. pp. 310–311, 1897) remarks that the view taken by Anthony as to the exothermic character of the reactions in the Jacques cell involves the

idea that the electrolyte undergoes no chemical change except by combination with carbon dioxide; that the electrical energy is due in part to the direct combustion of carbon with free oxygen instead of oxygen derived from the decomposition of the electrolyte, and in part to the secondary reaction involved in the formation of carbonate. For voltaic action some compound must be decomposed. As all the possible decompositions are endothermic, absorption of heat is necessary and the action cannot be voltaic. Referring to the question of two electrodes of the same metal at different temperatures, the reaction in this case cannot be voltaic, for if the conditions could be maintained so that no loss of heat took place, the arrangement would constitute an inexhaustible source of electrical energy. **W. A. Anthony** (Amer. Electn. 9. p. 351, 1897) in reply, remarks that reduction of Fe_2O_3 to FeO is a possible reaction which is not included by Reed, and that the effect of oxygen forced into the cell at the other electrode should not be neglected. No assumption should be based upon the action at one electrode only. On the whole, more energy is evolved within the cell than is sufficient to account for the electrical energy developed, and the cell would maintain itself hot after the action has once commenced if sufficiently protected by a non-conducting covering. There is plenty of energy for the required reaction. Oxygen is ready to combine with the freed ions before they have united to form physical masses. Decomposition takes place just as in any other galvanic cell, being determined by the affinities at both ends of the line. Only the final result need be considered, without the intermediate steps. A certain amount of energy may be necessary to cause decomposition when ions are aggregated into physical masses, but it does not follow that the same amount of energy is required when some other substance stands ready to seize upon the molecules of the ion as fast as they are liberated, forming a new compound with evolution of energy. With regard to two electrodes of the same metal at different temperatures, Anthony does not suppose that a continuous supply of energy could occur. If iron, for example, is dissolved at one electrode, it is not necessarily deposited at the other. The energy probably comes from chemical action within the electrolyte, due partly to absorption of oxygen. **C. J. Reed** (Amer. Electn. 9. pp. 351–352, 1897) recapitulates his previous objections to a voltaic theory, and then remarks that, because the oxidation of the carbon furnishes enough energy to account for the electrical energy developed, it does not follow that the energy is sufficient to decompose the electrolyte. The question is not whether the cell evolves less electrical energy than that contained in the carbon consumed, but whether it could be accomplished through decomposition of the electrolyte without absorption of external heat. The reduction of Fe_2O_3 to FeO, as proposed by Anthony, would require more energy than the carbon contains. Moreover, at the temperature of the cell, carbon would reduce this to metallic iron; besides which, ferric oxide is insoluble in the alkali and would thus

not form an electrolyte. Further, Elihu Thomson has shown that metallic iron and not ferrous oxide is formed at the cell-wall. **W. A. Anthony** (Amer. Electn. 9. p. 392, 1897) does not deny that the energy evolved in the oxidation of the carbon is insufficient to decompose the electrolyte, but such is of no consequence. Oxygen is forced in through the positive electrode and thus acts as a depolariser, the reaction being similar to a two-fluid cell. Its effect cannot be neglected, and it is certain that the union of the oxygen with the positive ion furnishes exactly the energy required for the decomposition of the electrolyte. **C. J. Reed** (Amer. Electn. 9. pp. 392–393, 1897), in reply, compares the Jacques cell to an exhausted Daniell through which air is forced. As to oxygen being a depolariser, it in no way resembles depolarisers in two-fluid cells. In the latter, the depolarisers are decomposed in strict accordance with Faraday's law. Oxygen is supplied by reduction of some compound, not from a fluid impregnated with free oxygen. W. R. C.

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659. *Electricity direct from Coal.* **C. J. Reed.** (Elect. World, 31. p. 92, 1898.)—The author refers to the cell invented by S. H. Short, consisting of carbon immersed in fused lead oxide, the other pole being a mass of melted lead. This arrangement is preferable to the Jacques cell inasmuch as CO_2 is the only by-product. In most primary batteries an expensive part of the mechanical structure is destroyed, the cost of which is greater than that of the necessary active material. If a suitable containing vessel can be found, this should not be the case in the Short cell. The reaction is simply one of displacement of lead by carbon.

W. R. C.

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660. *Borchers' Cells.* **C. J. Reed.** (Elect. World, 31. pp. 125–127 & 190–191, 1898.)—The author criticises the various carbon consuming cells invented by Borchers. The action of the first cell, described in 1894, cannot be due to the oxidation of CO and reduction of cuprous chloride, as stated, for such a reaction absorbs heat. The heat of formation of cuprous chloride, on the other hand, from cupric chloride is sufficient to account for the E.M.F. observed. Various omissions are pointed out in the description of the later cells. In the 1894 cell the CO electrode was negative, while in the 1897 cell it is positive. Some experiments are described, which cannot be well abstracted, showing that, contrary to the statement of Borchers, the results depend partly upon the nature of the electrodes and very little upon the gases that are introduced. W. R. C.

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661. *Blumenberg Carbon Consuming Cell.* (Indus. & Iron, 24. pp. 227–228, 1898.)—This cell consists of a carbon plate immersed in a fused electrolyte of lime, cryolite, and caustic soda contained

in a metallic bath. Steam is forced through the electrolyte, which should contain oxides or oxygen-bearing compounds. These give up oxygen to the carbon, forming CO and CO_2, and then apparently take up oxygen again from the decomposed steam. In place of oxygen-bearing compounds, natural metallic oxides may be used, in which case the metals are reduced. W. R. C.

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662. *Koepsel's Instrument for measuring Magnetic Induction.* **H. Kath.** (Zeitschr. Instrumentenk. 18. pp. 33–39, 1898.)—This is an improved form, brought out by Siemens & Halske, of Koepsel's instrument for the direct reading of magnetic induction in test bars (Zeitschr. Instrumentenk. 14. p. 391, 1894). It may be described as a D'Arsonval galvanometer used inversely, *i. e.*, instead of measuring the current in a movable coil suspended in a field of constant strength, it measures the field when a constant and known current is sent through the movable coil. It consists of a heavy soft iron semicircular yoke, with a magnetising coil, without iron core, along its diameter. The test rods, 6 × 24 mm., are inserted in the axis of the coil through holes in the yoke. In the centre of the yoke is pivoted a coil with pointer similar to that of the Weston instruments. The magnetising effect of the fixed coil when without the test core is compensated for by two windings on the yoke in series with the coil and acting in opposition. Auxiliary apparatus is provided as follows:—A circular resistance-box for giving the magnetising current suitable values for taking a cycle; another resistance-box with three dials for fine adjustment for regulating the current through the movable coil to the value required for direct reading, namely, the constant of the instrument divided by the section of the test-rod in sq. cms.; a special plug switch-board in connection with a Siemens & Halske milli-ammeter, which latter measures the movable coil current directly, and the magnetising current when shunted. A deflection of 1° on the shunted ammeter, corresponding to 0·01 ampere, gives unit magnetising force. G. H. Ba.

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663. *Koepsel's Instrument for measuring Magnetic Induction.* **E. Orlich.** (Zeitschr. Instrumentenk. 18. pp. 39–43, 1898.)—The paper describes experiments undertaken at the Physikalisch-Technische Reichsanstalt on the old and new forms of Koepsel's instrument (Abs. above). The B. H. curves of soft iron and steel were taken by the two forms of the instrument and also on the large yoke of the Reichsanstalt. The results show that for soft iron the new instrument gives exceedingly accurate values, and for steel somewhat less accurate but sufficiently so for all practical purposes. The new instrument shows a marked improvement over the old. The following points have to be attended to in using the instrument:—It must be so placed that the earth's field

has no effect; all magnetic bodies and masses of iron must be kept at a considerable distance; the test-rods must not project beyond the yoke. G. H. BA.

664. *Magnetic Susceptibility of Liquids.* **G. Jäger** and **S. Meyer.** (Wien. Akad. Sitzber. 106. pp. 594–622, pp. 623–653, 1897.)—The first paper contains a description of the apparatus used, and also gives the results of experiments on water and on solutions of ferric chloride; and the second paper gives the results of experiments on solutions of the chlorides, sulphates, and nitrates of iron, manganese, cobalt, and nickel. The liquid to be experimented on was placed in a **U**-tube having a very long horizontal bottom part. One of the vertical limbs was placed between the poles of a large ring electro-magnet, and the meniscus in this limb stood at the level of the centre of the pole-pieces. The other limb was connected above to a closed cylindrical air-chamber which was again connected to a capillary mercury manometer. When the magnet was excited a displacement of the meniscus between the poles resulted. To restore the meniscus to its former level, a certain change had to be made in the pressure of air in the air-chamber, and this was effected by altering the volume of the air by means of the mercury in the manometer. The change in the volume of the air was read off on the graduated limb of the manometer, and the change in pressure calculated therefrom by Boyle's law, the total volume of air being known.

The strength of field was calculated from the damping of a small closed rectangular circuit when set to vibrate in the field. For this purpose the small circuit was attached to a pendulum whose axis of suspension coincided with the long diameter of the circuit. The damping being measured when the magnet was excited and when not, and the moment of inertia of the pendulum being known, the strength of field was easily calculated.

The experiments with water were made at temperatures from 2° C. to 90° C., and with field-strengths varying from 100×10^6 to 300×10^6 C.G.S. The susceptibility is independent of the magnetising force, but not of the temperature. It is given for water by the expression

$$\kappa = -0{\cdot}647(1-0{\cdot}00164\,t)10^{-6}.$$

With all the solutions experimented on, the authors find that the susceptibility is independent of the magnetising force and is proportional to the number of gramme-molecules per litre of solution. The temperature coefficients are negative but vary with the concentration. The susceptibilities appear to be due only to the metallic part of the salt, as the same values are obtained for it per molecule, from solutions of chlorides, sulphates, and nitrates of the same metal. The susceptibility per molecule of nickel, chromium, cobalt, iron, and manganese at the same temperature appears to be proportional to the numbers 2, 3, 4, 5, 6 respectively. J. B. H.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

665. *Speed of Chemically acting Molecules in a Gas.* **M. Cantor.** (Annal. Phys. Chem. 62. 3. pp. 482–489, 1897.)—A metal plate immersed in a gas which acts chemically upon it undergoes less pressure than if it were unacted on, since some of the molecules which impinge on it are not reflected from it. Assuming these molecules to be those with energy between given limits or with speeds between v_1 and v_2, the pressure on the plate is less than on an inactive plate by $K=\frac{1}{6}\rho\int_{v_1}^{v_2}v^2dV$, and the plate will increase in mass by $\mu=\frac{1}{4}\rho\int_{v_1}^{v_2}vdV$ per unit time and area, if ρ is the density of the gas and dN the proportion of molecules with speed between v and $v+dv$. Thus $3K/2\mu=\int_{v_1}^{v_2}v^2dN/\int_{v_1}^{v_2}vdV$ may be roughly taken as a measure of the speed of the active molecules.

The author placed a copper plate in chlorine and found $\mu=\frac{1}{3}\times10^{-6}$ gm. per sec. per sq. cm.; he also hung it with its plane vertical and with the front of one half and the back of the other covered with glass, and on substitution of chlorine for air found deflections which indicated $K=1070$, 1700, 1820 microbarads in three separate experiments, the first with a bifilar and the others with a single quartz suspension. Taking 1530 as the mean value, we obtain 69 metres per second as rough estimate for the speed of the active Cl molecules. These experiments were repeated with Cu in NH_4Cl, but the results are withheld for the present for more careful discussion. R. E. B.

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666. *Mobility of Molecules.* **H. Euler.** (Annal. Phys. Chem. 63. 1. pp. 273–277, 1897.)—The author has measured the velocity of diffusion of the halogens by a method analogous to Scheffer's, and infers from the results that the diffusion-coefficients of the *molecules* Cl_2, Br_2, I_2 in water, as well as in other solvents, are *ceteris paribus* inversely proportional to the square roots of their molecular weights. Results of Hüfner are quoted for aqueous solutions of gases, which appear to follow a similar law. There appears to be no simple connection between the atomic weight of inorganic ions and their mobility as determined by electrolysis: this the author thinks may be accounted for by the hydration of the ions.

G. B. M.

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667. *Phase-rule and the Physical Properties of Chemical Compounds.* **F. Wald.** (Zeitschr. phys. Chem. 24. pp. 315–324, 1897.)—Gibbs' rule $v=\nu+2-r$, connecting the number of independent

variations of a system (n) with the number of phases (r) and the number of independent elements (ν), is discussed in detail, especially the particular case of $r=\nu$, which "supplies the key to the understanding of the gaseous laws and makes intelligible other physical relations between chemical compounds." The laws themselves, however, are not deducible from the principles laid down.

R. E. B.

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668. *Chemical Action of Electric Oscillations.* **A. v. Hemptinne.** (Zeitschr. phys. Chem. 25. pp. 284–299, 1898.)—Volatile liquids were submitted in the form of vapour at 15 mm. pressure to electric oscillations from a Lecher's apparatus for a few minutes up to two hours, and were all found to be decomposed. Analysis of the gases show that methyl and ethyl alcohols give large quantities of methane and ethane respectively, with 20–30 °/₀ CO, some CO_2, and 25–30 °/₀ H_2. The author concludes that O is first split off, which then attacks the hydrocarbon. Decomposed in presence of phosphorus, to absorb the O, ethyl alcohol yields much less CO. The decomposition of propyl, isopropyl, and allyl alcohol indicates a similar phenomenon. Aldehyde, paraldehyde, and acetone seem to first split off CO: the presence of P has no effect on the decomposition products. Acetic and propionic acids apparently split off O_2 at first; formic acid yields CO_2 and H_2. The isomeric esters, methylacetate and ethylformate, yield identical products, in contradistinction to the isomers allylalcohol, propylaldehyde, and acetone. The author concludes that the point of greatest weakness to mechanical [electrical] stress is not to be determined from constitutional formulæ derived from chemical reactions. Liquids and solid substances are decomposed by the direct action of the oscillations. Glycerine gives CO_2, CO, and H_2; glyceric acid gives, in addition, 20 °/₀ methane. Glycol gives 12 °/₀ methane, and seems to decompose into $CH_4+CO_2+3\,H$. Glyoxal, glycollic acid, oxalic acid, benzene, phenol, and benzoic acid are decomposed.

B. B. T.

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669. *Interrelations of Chemical and Electrical Energy.* **J. Klaudy.** (Zeitschr. Elektrotechn. Wien, 16. pp. 55–57, 151–153, 161–163, 1898.)—An epitome of recent theories on the chemical action in primary cells, their resistance and electromotive force.

B. B. T.

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670. *Boiling-points of Salts in Ethereal Solution.* **R. Lespieau.** (Comptes Rendus, 125. pp. 1094–1096, 1897.)—Using Raoult's apparatus, it has been found that it is not possible to deduce from a single measurement the molecular weight of a salt dissolved in ether. The numbers obtained vary very rapidly with concentration, and the limit towards which they tend when the concentration diminishes indefinitely should be sought. This limit has been

calculated assuming (which graphic treatment of the results shows to be allowable) that the curves obtained on taking as abscissæ the rise in boiling-point Δ_T, and as ordinates the ratio of Δ_T to the quantity of the substance dissolved, are straight lines. The numbers got by the application of Raoult's methods may be multiples or sub-multiples of the true molecular weight. J. J. S.

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671. *Freezing-points of Benzene Solutions.* **R. Mihály.** (Zeitschr. phys. Chem. 24. pp. 13–17, 1897.)—In a solution of 3·9994 grams of alcohol in 17·15 grams of benzene the molecular weight of the alcohol, calculated from the freezing-point of the solution, corresponds to the formula 4·83 $C_2H_5(OH)$. When water is added to this solution the freezing-point rises in proportion to the quantity of water added, the elevation being very nearly that which would be expected if the water added combined with the alcohol to form the hydrate $9C_2H_5(OH)+3H_2O$. When about 11·5 % of water has been added, the solution becomes non-homogeneous and the freezing-point rises more slowly than before. Similar results were obtained with solutions of phenol and acetic acid in benzene; in the latter case the solution becomes turbid after the addition of one or two drops of water. Substances such as glycerol or lactic acid give results similar to those observed with water. T. E.

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672. *Electrolytic Conductivity of Salts in Pyridine.* **St. v. Laszczynski** and **St. v. Gorski.** (Zeitschr. Elektrochem. 4. pp. 290–293, 1897.)—The conductivity of KI, NaI, NH_4I, LiCl, KCNS, NaCNS, and NH_4CNS are determined in solution in pyridine. The first three and the last converge to a limit of 40 to 45 for the molecular conductivity at infinite dilution at 18° C. LiCl is very slightly dissociated, which the author connects with the fact that it forms a compound, $LiCl+2C_5H_5N$. Attempts to obtain the alkali-metals by electrolysis in pyridine succeed only in the case of lithium. The following salts did not conduct in pyridine—$MgCl_2$, $CeCl_2$, $CaCl_2$, $CoCl_2$, and AgI. B. B. T.

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673. *Electrochemical Theory.* Part II. **R. Mewes.** (Elektrochem. Zeitschr. 4. pp. 167–173, 1897.)—An account, from an historical and philosophical standpoint, of some points in chemical theory. Atomic weights, atomic volumes, heats of combustion, and the unity of the chemical elements are here discussed. J. W.

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674. *Electrolytic Production of Iodoform.* **F. Foerster** and **W. Mewes.** (Zeitschr. Elektrochem. 4. pp. 268–272, 1897.)—A patent for the production of iodoform by electrolysis of an alcoholic solution of potassium iodide was obtained by Schering in 1884;

and a short time ago, at the instigation of one of the present authors, the reaction was investigated by Neubert. He showed that it was necessary to add a certain amount of alkaline carbonate, and to raise the temperature to about 60°. The passage of a stream of carbon dioxide through the electrolyte was also found to be indispensable. The subject has recently been investigated by Elbs and Herz, whose results agree in the main with those of Neubert, but they state the use of carbon dioxide to be unnecessary. It was to explain this discrepancy that the present work was undertaken. The authors agree with Elbs and Herz in representing the formation of iodoform by the equation

$$C_2H_6O + 5\,I_2 + H_2O = CHI_3 + CO_2 + 7\,HI.$$

Their experimental conditions differ from those obtaining in the work of Elbs and Herz chiefly in that the use of a porous cell is avoided and the kathode simply enveloped in parchment-paper. Not only is the resistance thus greatly diminished, but the alkali formed at the kathode easily mixes with the fluid round the anode, and prevents the formation of free acid. Now the above equation shows that for every 10 equivalents of iodine separated at the anode only 7 equivalents of acid are produced, while 10 equivalents of free alkali are formed at the kathode; and, since free alkali is prejudicial to the production of iodoform, a stream of carbonic acid is therefore required to convert the excess into carbonate. If, on the other hand, a porous cell is used, the fluids mix much more slowly, and there is a tendency to the production of free acid at the anode: in this case, therefore, carbonic acid is unnecessary, and addition of alkali is rather required. The discrepancy between different observers is thus simply due to the difference in the experimental conditions, and emphasises the importance of strict attention to the latter in electrolytic work. In this instance the object to be attained in all cases is the maintenance of a certain slight alkalinity at the anode. J. W.

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675. *Electrolysis of Aqueous Solutions.* **L. Glaser.** (Zeitschr. Elektrochem. 4. pp. 355–358, 373–379, 397–402, 424–428, 1898.) —The paper is divided into three parts. Part I. deals with the experimental determination of the E.M.F. of the hydrogen-oxygen couple (1·08 volt) and its temperature-coefficient (0·00143); and on the influence of the concentration of the electrolytes, of other solvents than water, and of hydrogen peroxide. The measurements fully confirm the conclusion previously arrived at by Smale that the formation of water in the gas-couple is a reversible process.

Part II. treats of the decomposition of water. The effect of an E.M.F. ranging from 0 to 1·67 volt on solutions of acids was studied, and the observed deflections of the galvanometer plotted against the E.M.F.'s: the curve shows a distinct break at 1·08

volt, the value obtained for the O-H couple. It is therefore permissible to speak of a two-fold point of decomposition of water, at 1·08 volt and at 1·67 volt. In the former case, the O and H ions are of course doubly charged; they exist in the solution in relatively small numbers, and hence the point of decomposition is ill-marked and easily overlooked. On the other hand, at the E.M.F. of 1·67 volt, H and OH ions are separated in comparatively large numbers: the latter of course undergo a secondary reaction of the anode.

In Part III. the points of decomposition of the dissolved electrolytes are dealt with, and the conclusion arrived at is that the decomposition of water, even if it can be brought about primarily to a great extent, is in reality accomplished principally in a secondary manner. J. W.

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676. *Electrolytic Preparation of Perchloric Acid and its Salts.* **F. Foerster.** (Zeitschr. Elektrochem. 4. pp. 386–388, 1898.)—The fact that chlorates when electrolysed in neutral or acid solution are oxidised to perchlorates at the anode was noticed by Stadion in 1816, and again in 1847 by Kolbe. The author now studies the influence of concentration, temperature, and current-density on the course of the reaction, which is shown to be capable of development into a simple and practical process. The best results are obtained by the use of concentrated solutions and a fairly high current-density; a rise of temperature greatly diminishes the yield. Owing to the sparing solubility of potassium chlorate at ordinary temperatures, it is best to electrolyse a solution of sodium chlorate, and obtain the potassium salt by double decomposition with potassium chloride. This conversion of chlorates into perchlorates proceeds equally well in acid solutions. With alkalies, however, the oxidising action of the current is only observed at the commencement of electrolysis, and it is even then inconsiderable, and very soon ceases altogether. From this it appears that the immediate conversion of chlorides into perchlorates is impracticable, since chlorates, the intermediate product, alone are obtained by electrolysis in alkaline solutions.
J. W.

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677. *Electrolytic Iron.* **F. Haber.** (Zeitschr. Elektrochem. 4. pp. 410–413, 1898.)—This is a description of the iron stereotype-plates from which the notes of the Austro-Hungarian bank are printed. The metal is precipitated by a very feeble current from a solution of ferrous and magnesium sulphates. It contains about twelve times its volume of hydrogen, and this peculiarity is discussed at length. J. W.

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678. *Electrolytic Reduction of the Nitro Group.* **W. Löb.** (Zeitschr. Elektrochem. 4. pp. 428–437, 1898.)—This paper deals with the chemical nature of the substances obtained by the electro

lytic reduction under various conditions of nitrobenzene and paranitrotoluene. J. W.

679. *Electrolytic Separation of Cadmium and Zinc, Zinc and Cobalt, and Antimony and Tin.* **A. Waller.** (Zeitschr. Elektrochem. 4. pp. 241–247, 1897.)—The author discusses the merits of the processes which have been proposed by previous observers, whose experiments he has in many cases repeated and extended. The following methods are stated to be the best, the separation depending in each case on the E.M.F. in the electrolytic cell being sufficient to cause the decomposition of the salt of the one metal, whilst insufficient for that of the other.

Cadmium and Zinc. The solution of the chlorides of the metals is mixed with potassium and ammonium oxalates. The temperature should be at about 80–85°, and the E.M.F. not more than 0·3 volt above that required for the decomposition of the cadmium salt.

Zinc and Cobalt. The sulphates are dissolved in water containing some Rochelle salt, caustic soda, and a little potassium iodide. The temperature is kept at 60–65°, and the E.M.F. at about 2 volts. The use of potassium iodide diminishes, but does not entirely prevent, the deposition of a small amount of cobaltic oxide on the anode. The latter is therefore weighed before and after the electrolysis, and a suitable correction made.

Antimony and Tin. The salts of the metals are dissolved in perfectly pure sodium sulphide solution to which a little caustic soda is added. The temperature is conveniently kept at about 65°, and the E.M.F. should not exceed 0·7 volt. J. W.

680. *Electrolytic Separation of Cadmium and Iron.* **W. Stortenbeker.** (Zeitschr. Elektrochem. 4. pp. 409–410, 1898.)—The mixed salts of the metals are dissolved in water faintly acidified with sulphuric acid, 2 or 3 grams of pure potassium cyanide added, and the mixture heated until a clear yellow solution is obtained. This is electrolysed in the cold, using a weak current of 0·05 to 0·1 ampere. If much ferric salt is present it is reduced with sodium bisulphite. The best analyses given are very satisfactory. J. W.

681. *Thermic Equilibrium in Electrolysis.* **D. Tommasi.** (Elect. Rev. 42. p. 61, 1898.)—The author considers how a compound which is capable of both oxidation and reduction will behave when subjected to oxygen and hydrogen by electrolysis, and concludes that the reaction that evolves most heat will take place, provided that it can begin. Further, the reaction that requires least heat to begin will take place in preference to the other. W. R. C.

682. *Carbon Electrode with Multiple Copper Leads.* **K. W. Hertel.** (Elektrochem. Zeitschr. 4. pp. 174–175, 1897.)—The electrode consists of a block of gas-carbon of any suitable form, provided with a number of apertures holding a copper fitting in immediate contact with the carbon. The apertures in the fitting are filled with copper oxide or manganese dioxide, in which the copper leads are immersed; the other ends of the leads are connected by a metal strap. A diagram is given. J. W.

683. *Electrolysis in Gold Extraction.* **E. Andreoli.** (Elektrochem. Zeitschr. 4. pp. 149–155, 1897.)—The merits of the electrolytic and zinc-precipitation processes for the extraction of gold from cyanide solution are discussed, and preference given to the former. A larger outlay is required for the plant, but the cost per ton of material treated is one-sixth less than in the zinc process. The writer advocates the use of lead peroxide plates at the anode, the gold being deposited on iron kathodes. The latter are finally immersed in a bath of molten lead, to dissolve the gold, and are then ready for further use. J. W.

684. *Electrolytic Gold-Refining.* **E. Wohlwill.** (Zeitschr. Elektrochem. 4. pp. 379–385, 402–408, 421–423, 1898.)—A number of observations arising from the practice of electrolytic gold-refining, which the author suggests may be of value in affording confirmations and proofs of various electrochemical facts and theories. The paper is unsuited for abstraction. J. W.

685. *Electrolytic Bleaching of Cotton.* **H. Wartner.** (Elektrochem. Zeitschr. 4. pp. 261–263, 1898.)—A solution of rock-salt is electrolysed with the formation chiefly of hypochlorites, and the liquid is stored in closed vessels for use when required. Under certain conditions of working, the process is cheaper than the use of bleaching-powder in the ordinary way, and is already successfully carried on in various parts of Germany. The cost of the plant required is dealt with. J. W.

686. *Electrolytic Zinc: the Hoepfner Vat.* (Indus. & Iron, 24. p. 208, 1898.)—This is a short description, illustrated with five figures, of the recently patented Hoepfner apparatus and process for recovering zinc from zinc-chloride solutions. A V-shaped trough is divided transversely by means of diaphragms into an equal number of anode and kathode compartments. In the former, flat carbon anodes are fixed in suitable frames, while circular zinc or iron plates mounted upon a central shaft running the length of the vat function as kathodes and revolve with their

lower halves immersed in the electrolyte contained in the kathode compartments.

The construction details by which the framework of the vat is made with channels to provide the necessary supply and circulation of the zinc-chloride solution are also described, and form part of the Patent claim. The design of the vat is such, that when necessary it may be suspended from girders, and a bottom support be dispensed with. J. B. C. K.

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687. *Zinc Extraction by the Ashcroft Process.* **R. Threlfall.** (Elektrochem. Zeitschr. 4. pp. 189–196, 1897.)—This is a lengthy illustrated article dealing with the chemistry of this electrolytic extraction process, and describing the plant erected at Cockle Creek, New South Wales. The process has been often described in the English Technical Journals (see 'Cantor Lectures,' 1896, Swinburne); and the only new feature introduced is that the solution of zinc used in the kathode chambers is made basic, either by the addition of zinc oxide or of an alkaline hydrate. The patentee considers that better results are obtained from such solutions than from neutral or acid solutions.

The plant at Cockle Creek was erected, but was not in operation at the date of writing. The generating plant consists of 5 Babcock boilers, which supply steam to 5 Willans high-speed engines, direct-coupled to 5 Siemens dynamos. The smaller dynamos deliver 1100 amperes at 120 volts pressure, the larger ones double this amount. Each unit of generating machinery has its own switch-board. The vat-shed is 175×100 feet. The vats are raised upon iron supports about 5 feet above the ground, and each vat is connected by caoutchouc tubing to the lead supply-pipes. The material of the vats is Californian redwood; they are each $6 \times 6 \times 6$ feet, and each is divided into four compartments by means of canvas and wood. Each of these compartments contains 12 kathodes and 13 anodes, 4 feet long by 1 foot broad. This small size has been chosen, in order that the anodes may be easily handled by the workmen. The anodes are of carbon and of iron; the kathodes are of rolled zinc $\frac{1}{25}''$ thick. The electrodes in each vat are worked in parallel, the vats in series. The E.M.F. per vat varies from 1 to 2·8 volts, according as iron or carbon is used as anode material. Each electrical circuit contains 48 vats with iron anodes and 24 with carbon anodes; these 72 vats demand 120 volts when worked in series. Figures are given in the original article to elucidate the arrangement of the electrodes and the plan of current distribution. A current-density of about 5 amperes per sq. foot is used, and the area of the kathode-surface in a double vat $(12' \times 6' \times 6')$ suffices to allow a current of 5000 amperes to pass through the system.

The author considers that Ashcroft's views concerning the character of the deposits obtained from basic zinc solutions require further confirmation. He states that the current-density used is

not of importance, if the solutions be of the right constitution and concentration to give dense metallic deposits of zinc. Under these conditions either 2 or 100 amperes per sq. foot may be employed. The variation in the physical character of the zinc deposits that are obtained from solutions which, from the chemical point of view, are similar in every respect, he attributes to the presence of minute quantities of unrecognised elements in the solution. The detection of these, and study of their influence, he considers the technical electro-chemical problem of the present time. J. B. C. K.

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688. *Electrolytic Pickling.* **S. Cowper-Coles.** (Elect. Rev. 42. p. 63, 1898.)—A vat is described for this purpose. Any scale that becomes detached may be collected magnetically in the acid electrolyte, if this is caused to flow past electromagnets. W. R. C.

GENERAL ELECTRICAL ENGINEERING.

689. *Variation of E.M.F. and Efficiency of Lead Accumulators with Strength of Acid.* **F. Dolezalek.** (Zeitschr. Elektrochem. 4. pp. 349–355, 1898.)—It is contended that the theory of Liebenow, which regards the accumulator as a reversible cell, is the only one which can be consistently maintained, and with which the behaviour of the cell is in agreement. The differences in the E.M.F. of accumulators with different concentrations of acid are shown to be in excellent accordance with the values calculated by two independent methods based upon thermodynamical considerations. The efficiency of the accumulator amounts on the average to 75–85 %, although 94–97 % of the current used in charging is recovered on discharging. This is caused by the difference in E.M.F. during charging and discharging, which has led to the belief that the action is only partially reversible. This difference is attributed to mechanical hindrances to the equalisation of acid concentration in the neighbourhood of the electrodes, whereby the accumulator behaves during charging as if filled with a stronger acid, and during discharge as if filled with a weaker acid, than is really the case. It is calculated that the accumulator should work with maximum efficiency when filled with acid of maximum conductivity (30·4 % H_2SO_4). Here also experiment is in close agreement with theory. J. W.

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690. *Storage Batteries.* **E. J. Wade.** (Electrician, 40. pp. 350–351, 444–446, 591–593, & 757–759, 1898.)—A series of articles dealing with the construction of storage batteries.
W. R. C.

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691. *Accumulator Construction.* **D. Fitz-Gerald.** (Elect. Engin. 21. pp. 14–15, 39–41, 72–74, 103–105, 136–137, 170–172, 199–202, 230–231, 262–263, 299–301, 328–330, 393–395, & 518–519, 1898.)—A series of articles dealing with the construction of storage batteries. W. R. C.

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692. *Kelvin's Instruments.* **M. Maclean.** (Elect. Engin. 21. pp. 231–233, 301–303, 337–339, 358–359, 390–393, & 421–423, 1898.)—An abstract of a paper read before the Philosophical Society of Glasgow, and descriptive of Kelvin's well-known electrical instruments. W. R. C.

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693. *Temperature Coefficient of Thomson Meter.* **W. L. Hooper.** (Elect. World, 31. p. 384, 1898.)—The author refers to the work of G. W. D. Ricks on this subject, who obtained the value $-0{\cdot}0032$ for the coefficient (Elect. World, 9. p. 248, 1897).

and describes the methods and apparatus used by himself in testing four Thomson meters of American manufacture. Experiments were made at temperatures between 0° C. and 44° C. with various loads, giving a mean value for the coefficient of −0·00048. The results are not very concordant, ranging between −0·00030 and −0·00060; the author accounts for this on the ground that a small error in determining the constant of the meter causes a very large error in the value of the coefficient. The author concludes that a greater error than 1 per cent. in the record of the meter is not likely to occur in practice, and suggests a possible explanation for the high value obtained by Ricks. A. H. A.

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694. *Water Rheostats.* (Electrician, 40. pp. 696–697, 1898.)—Water rheostats may be used where a non-inductive load is required to absorb a large amount of electrical power. If the voltage is less than 1000, the conductivity of the water should be increased by the addition of a solution of sodium sulphate. In some tests of a 450-kilowatt 500-volt three-phase plant at Bakersfield water rheostats were used. They consisted of three separate redwood tanks, each measuring 4 ft. by 4 ft. by 6 ft., and each containing two sheet-iron electrodes of such size as to give 5 in. in the clear when suspended in the tanks. Three of the six electrodes, one from each tank, were coupled together in short circuit, while the three legs from the three-phase generator were each taken to the remaining electrode of its respective tank. Each phase was thus provided with a rheostat capable of absorbing 150 kilowatts. The amount of sulphate of soda was so regulated that the rheostats would carry a load of 500 H.P. for three hours without boiling. In order to keep the temperature low, and to wash off the bubbles of oxygen and hydrogen from the electrodes, it is advisable when high voltages are used to keep a constant circulation of water through the tank. W. G. R.

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695. 200-*Volt Lamps and Apparatus.* **G. Binswanger-Byng.** (Electrician, 40. pp. 654–657, 685–689, 1898.)—The author discusses mainly the modifications which have been rendered necessary in incandescent lamps, arc lamps, switches, cut-outs, and other fittings, to adapt them for use on 200-volt circuits.

Incandescent Lamps.—In order to reduce the length of the filament required so as to enable it to be arranged within the same size bulbs as are used for 100-volt lamps, the makers have employed unflashed filaments which have a higher specific resistance. The C.P. and efficiency, however, fall off more rapidly than with flashed filaments. Some tests showed that in the average unflashed 200-volt 16-c.p. lamp, the percentage loss of candle-power in 600 hours is about 42 %, and the average drop in efficiency is about 35 %, the surface of the filament becoming dull, sooty, and often full of small pit-holes. Robertson finds that carbon of lower specific resistance (flashed) is less volatile than unflashed carbon, and therefore better

retains its original candle-power and efficiency whilst being mechanically stronger. The average specific resistance of 200-volt unflashed lamp carbon is 3500–5000 microhms per c.c., whilst flashed carbon is easily obtained of 2400 microhms per c.c. The author therefore prefers to use flashed filaments, employing a bulb of slightly larger size. He advocates the use of a non-metallic cap and a lamp having a single filament arranged so as to withstand the disturbing effects of gravity and electrostatic charges on the bulb.

Switches, Cut-outs, etc.—Drawings are given of several types of switch, ceiling-rose, wall-plug, lamp-holder for use on 200-volt circuits, and also of a new form of cut-out, the principal feature of which is the employment of a *fuse-chamber, i. e.*, a round china wall forming a central hole from $\frac{1}{2}''$ to $1''$ diameter, and pierced with two holes near the terminals which are fixed on the base outside. The fuse-wire is threaded through diametrically-opposite holes in the fuse-chamber which is lined with plaster-of-Paris, this material not being liable to volatilise and feed the arc. Fuse-wires enclosed in glass tubes filled with plaster or cement, but with a free central space for fusion, are also satisfactory.

Arc Lamps.—Since, for economical working, it is necessary to work with four or five lamps in series, there is a danger of burning out the shunt coils of some of the lamps, if the carbons of one or more of the lamps should be short-circuited. The author proposes to protect the shunt-coils by means of temperature-fuses, or by an automatic cut-out and cut-in whereby the arc is first short-circuited through a shunt-path; this short-circuit is then broken by a quick-break switch, the same action reversing the shunt-switch simultaneously, ready to fall upon its normal contact when the carbons touch, or are replenished. This mechanism is actuated by the main armature of the lamp, these movements taking place when the armature is below the feeding-point.

In the discussion which followed this paper, **H. L. P. Boot** stated that there was less risk of explosions with fuses when using alternating currents than there was with direct currents. **C. H. Stearn** considered that, for the present transitional period, untreated filaments were the best, since they could be easily produced of greater uniformity than treated filaments. Treating, to be reliable, must be thick, and if properly treated a 16-c.p. 230-volt lamp would need a length of filament of $14''$ to $15''$. This should be bent backwards and forwards so that the whole length could be enclosed in a small compass and used in bulbs of the old size. He did not consider it necessary to put the filaments further apart. He considered it possible to use filaments containing boron, silicon, alumina, etc., and had seen some which contained at least one of these substances and did not show any material change in efficiency for 300 hours working at 2·8 watts per candle. **J. Swinburne** found that untreated filaments lasted better than treated ones; he, however, always flashed them *in vacuo*. **C. H. Wordingham**, in connection with supply at 200 volts, has specified that the length

of break in switches and fuses must be such as to permit a 50 °/₀ excess of current at a 50 °/₀ excess of pressure without arcing. With regard to cut-outs, he had specified that they must be capable of breaking a short-circuit with a fuse-wire in the cut-out. **H. W. Miller** stated that combination-filaments could be made to work at $2\frac{1}{2}$ watts so as to give as good results in c.p. and efficiency as a carbon filament working at $3\frac{1}{2}$ watts. He found that a satisfactory way of changing small fan-motors from 100 to 200 volts was to put the shunt-winding in series with the armature. **C. J. Robertson** preferred flashed filaments, and stated that lamps lasted better with alternating than with direct currents. He found that wavy-filament lamps were not suitable for horizontal burning unless supported, or made with unflashed carbons. **S. P. Thompson** preferred low voltages, and considered that improvements in incandescent lamps should lie in the direction of improving the carbon of the filaments. **J. W. Swan** considered that untreated carbon was still open to much improvement. **R. E. B. Crompton** said that arc-lamps had been run for years at Liverpool Street Station four in series on 200 volts, and that the number of shunts burnt-out had not amounted to 1 °/₀ per annum, although no such cut-outs were in use as were mentioned by the author. C. K. F.

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696. *Lightning-Protector.* **M. Aliamet.** (Électricien, 15. pp. 69–71, 1898.)—This apparatus, which is constructed by the Western Electric Co., and has been in use for several years in America for telephones, consists of a base having at one end two lateral terminals for the attachment of the line wires, and one in the centre for the earth-connection, and at the other end two lateral terminals for the telephone connections. The lateral terminals on each side are connected by a fuse arranged in series with a ferro-nickel resistance-coil of 27 ohms, and surrounded by an asbestos tube, the whole being mounted in a tube of vulcanised fibre provided with a terminal at each end. The point of junction between the coil and the fuse-wire is connected to a metal ring on the exterior of the fibre tube; this ring fits between metal springs on the base, which are each connected to one of a pair of contact-springs arranged in the centre of the board and having a central plate between them, which plate is connected to the "earth" terminal. Between each of these springs and the central plate is slid a lightning protector, consisting of two carbon plates separated by a sheet of mica having a hole in it. In one of the carbon plates is a recess registering with this hole, and containing a bead of fusible metal, so that, when sparks play through the hole in the mica, the metal will melt and short-circuit the carbon plates. If the discharge is insufficient to actuate the lightning-protector, it melts the fusible wire and thus interrupts the telephone circuit. If the discharge-current is too weak to fuse this wire, but is still of sufficient strength to be dangerous, it causes the circuit to be interrupted as follows, viz. :—The connection between the resistance-

coil and the fuse-wire is made through a strip of fusible metal which is thermally connected to the resistance-coil by means of a metallic bobbin on which this coil is wound. Against this metal strip the end of a glass rod is pressed by means of a spring, so that when the resistance-coil heats the fusible strip, the glass rod is forced through the said strip by the spring and breaks the circuit. C. K. F.

697. *Carbons for Electric Lighting and other Purposes.* **F. Jehl.** (Electrician, 40. pp. 476–478, 593–595, 797–799, and 826–827, 1898.)—A series of articles relating to the manufacture of carbons. W. R. C.

698. *Electric Machine Tools.* (Mech. Eng. 1. pp. 149–151, 1898.)—Adamson's, of Hyde, find utility not so much in the coal economy as in saving labour, absence of belt-slip enabling machines at heavy loads to maintain their full speed. Air and water under pressure are not discarded. A description is given of Perrett's furnace, in which the fire-bars are under water; also of a boiler-flanging press (hydraulic), plate-bending rolls (electric), and punching machine (electric). A boring machine up to 2′ × 2′ takes 17 amps. at 110 volts. Good figures are given of a hydraulic rivetter fed by an electric winch, a semi-portable drill, and a 10-cwt. electric crane supplied to the Royal Mint. M. O'G.

699. *Electrical Travelling Cranes.* (Mech. Eng. 1. pp. 196–198, 1898.)—Adamson's, of Hyde, obtain the following results with three motors to each crane:—

Lifting capacity, in tons	30	10	5
Speed, in ft. per min.	2·4	6·3	13·1
H.P. absorbed, full load	9	9·6	10·4
Efficiency, per cent.	54·35	56·3	46·9
Speed down shop, ft. per min. ..	80	100	160
H.P. absorbed in ditto	5	3·3	2·8
Speed traversing shop, ft. per min.	20	40·6	59·3
H.P. absorbed	3·1	1·35	0·85

The increased power in smaller cranes is due to increased speed of lifting. It is found that ropes for these cranes formerly took 5 H.P. per 100 ft., or in Adamson's shop 12 H.P. continuously wasted. Spur- or worm-gear are used for motor reduction. The travelling wheels are cast in one with the spur-wheels. The main axle is lubricated by a roller of wood floating in oil, by which means the lubricant is applied on what experiment proves to be the right place—where there is no pressure. M. O'G.

700. *Electricity in Factories.* **C. H. Benjamin.** (Mech. Eng. 1. pp. 98–99, 1898.)—Electric cranes and the rearrangement of

machines allowed by electric driving has, in the Baldwin Locomotive Works, reduced 40 labourers to 10, and the skilled time lost from 10 °/₀ to 2 °/₀. The absence of the dust and shadows cast by belts is remarkable. M. O'G.

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701. *Electricity on Board Ship.* **E. G. Tidd.** (Elect. Engin. 21. pp. 435–439 & 454–459, 1898.)—A fairly detailed description of plant, and applications of electricity on board ship. W. R. C.

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702. *Electricity in Mining Operations.* **F. A. C. Perrine.** (West. Electn. 22. p. 157, 1898.)—This article points out that the application of electrical power for mining purposes is at present defective, chiefly because electricians are not acquainted with the miners' requirements and miners themselves are usually ignorant of the principles underlying electrical engineering. The electric drills are defective, and cannot take the place of the pneumatic drill. Cables are not made suitable for mines, since they are usually too heavily insulated for vertical shafts, and lead-covering is attacked by acidulated water. Although electric elevators are successful for office and factory purposes, the application of the electric motor to hoisting when the power is derived from a long distance is not successful, especially when the hoist is required to stop and start frequently and has to run at different speeds. One of the most important of the applications of electricity to mining is electrolytic deposition; yet only the simplest cases can be thus dealt with. The application to the recovery of metals from leached liquors has not yet been investigated. W. G. R.

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703. *Edison's Magnetic Concentration Works.* (Elect. Rev. 42. pp. 188–191, 1898.)—An account is given of the method used in the magnetic concentration of low-grade iron ores in New Jersey, and of the preliminary treatment necessary. The actual amount of handling is very small. The excavation is effected by means of a 60-ton or a 93-ton shovel. A large number of rolls, the largest being 70 tons in weight, are used for crushing the ore. After screening through 14-mesh screens, the first magnetic separation is carried out by allowing the powdered ore to fall in a vertical stream past the electromagnets. Further concentration and screening is carried out; and finally the concentrated ore is made up into briquettes containing about 68 °/₀ of iron. This is necessary, as the blast furnaces cannot deal with powdered ore. The plant is capable of mining 5000 tons in 20 hours. W. R. C.

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704. *The "Little" Integrating Indicator.* (Electrician, 40. pp. 787–788, 1898.)—The purpose of this instrument is to obtain a numerical index of the work done by the engine in any given number of revolutions. The pulsations of steam-pressure in the indicator cylinder are caused to vary the angle

the integrator disc makes with the axis of a barrel against which it is lightly pressed, and which is oscillated by means of a cord from the engine crosshead. If the time it is in operation and the number of revolutions made by the engine be noted, either the mean H.P. or the total work done can readily be found. A. S.

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705. *New Governor for Hydraulic Motors.* **E. H. Rieter.** (Électricien, 15. pp. 145–152, 1898.)—In this apparatus any excess of energy above that required for the normal speed of the motor is absorbed by an electric brake. A mass of iron is rotated in a magnetic field, and consequently becomes heated by the Foucault currents generated; the heat is dissipated by providing efficient circulation of air. The exciting current, and therefore the work absorbed by the brake, is controlled by a centrifugal governor and rheostat, the latter having a number of points which may make contact with a bath of mercury. In many cases the speed-variation has been less than one per cent. for a sudden variation of 50 per cent. of the normal load. A. S.

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706. *Breakdowns from Priming.* (Elect. Rev. 42. pp. 356–357, 1898.)—Three Willans engines having been wrecked by sudden and excessive priming of one or more water-tube boilers, this paper discusses the use of separators and the arrangement of steam-piping with the view of supplying fairly dry steam to the engine. A. S.

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707. *Mechanical Stokers at Carnegie Steel Works.* (Elect. Rev. N.Y. 32. p. 133, 1898.)—The steam-generating plant recently installed at the Carnegie Steel Works, Pittsburgh, consists of a battery of 24 two-flue boilers, each 54 ins. diameter by 28 feet long, and is perhaps the largest and most complete plant of the kind. Each boiler develops 178 H.P., and the "American" mechanical stoker is used, one fireman attending to eight boilers. Using the cheapest grade of soft coal, hardly a trace of smoke is seen at the chimney-top. A. S.

DYNAMOS, MOTORS, AND TRANSFORMERS.

708. *Commutation in Dynamos and Motors.* **W. H. Everett** and **A. H. Peake.** (Electrician, 40. pp. 861–862, 1898.)—The object in view was to examine experimentally the reversal of the current in a "section" of the armature-winding while passing under either brush. A special split brush was used, consisting of two copper plates separated by vulcanised fibre. These plates were joined by a non-inductive resistance of 0·007 ohm, to the middle of which one main was connected. The resistance of an armature-section was 0·008; the machine was bipolar, with smooth-core ring armature wound with 60 sections, to give 45 amperes at 110 volts. The instantaneous P.D. across the non-inductive resistance, and hence the current of the coil under the brush, was found by charging a condenser, joined to the ends of the resistance, through a revolving contact-maker, and then discharging through a ballistic galvgnometer. By altering the position of the contact-maker, the current was found for different positions of the coil under the brush. The brushes were adjusted to avoid sparking. With the machine used as a motor, the current was found to reverse quickly, in a typical case, to about half its final negative value; it then diminished slowly, and finally rose again quickly. The final change is presumably due to decrease of contact-surface between brush and commutator-segment. A weaker field gives a more gradual reversal. Change of speed has little effect. With a smaller backward lead, a larger part of the reversal has to be effected at the last. With the machine used as a dynamo, the reversal is more nearly uniform throughout; but there may be excessive reversal, requiring a final *diminution* of the current by contact-resistance. And in some cases the current may *rise* at first. These results are such as we should expect. In a dynamo, the field for reversal lies in front of the neutral axis, and in a motor, behind it. Hence in a dynamo the brush must be in such a position that the neutral axis is near (or beyond) the heel, and in a motor near the toe. This explains the results. Further experiments are proposed. AUTHORS.

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709. *Patin Fly-Wheel Alternator.* (Engineer, 85. pp. 263–264, 1898.)—This is an illustrated description of a fly-wheel alternator made by Messrs. Patin & Co. In this machine the magnetic field forms an integral part of the driving-engine. The fly-wheel of the engine carries the field-magnets of the dynamo, and the armature is stationary but is capable of being slid out of the magnetic field by a lateral movement, thus permitting the coils to be revarnished when necessary. Details of two alternators of this type are given below. No. 1 was coupled direct to a turbine, and No. 2 to a steam-engine.

	No. 1.	No. 2.
Power produced, in watts	40,000	120,000
Voltage	2,400	2,400
Resistance of armature, in ohms......	4·5	0·96
Number of coils on magnets	24	104
Resistance of magnets, in ohms	4·8	2·5
Revolutions per minute	300	95
Efficiency, per cent.................	94	96
Power used for exciting (watts)	1,200	2,400

From these machines 12 lamps of 16 candle-power can be fed per horse-power developed. W. G. R.

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710. *Alternating-Current Motors.* **E. E. Tasker.** (Elect. Engin. 21. pp. 403–407 & 427–428, 1898.)—A paper read at a students' meeting of the Institution of Electrical Engineers. It deals generally with the theory and working of alternate-current motors. W. R. C.

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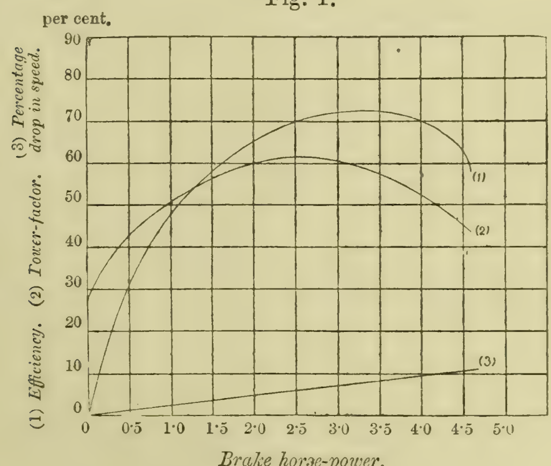
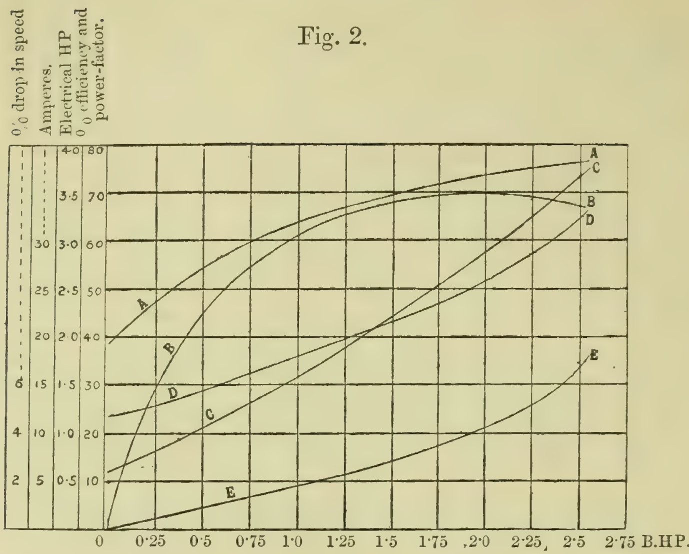
711. *Single-Phase Motors.* **A. C. Eborall.** (Elect. Rev. 42. pp. 432–433 & 500–502, 1898.)—These conclude a series of articles by the author on single-phase motors (see Abstract No. 444). Fig. 1 shows the efficiency, power-factor, and percentage drop of speed of a 3-H.P. six-pole motor, constructed

Fig. 1.



by Messrs. Brown, Boveri & Co., running at 100 volts and a frequency of 100 alternations per second. Fig. 2 gives the results of a test of a 2-H.P. Kolben motor, designed to run at 1500 revolutions per minute on a 110-volt circuit and at a frequency of 50 complete cycles per second. The curve AA

Fig. 2.



gives the power-factor, BB the efficiency, CC the power absorbed, DD the amperes at 110 volts, and the curve EE gives the percentage drop in speed. In the Kolben motors leakage is minimised by the magnetic separation of the stator core discs from the containing case. The performance of some single-phase Kolben motors is shown in the following table:—

Horse-power	0·2	0·75	2	3·5	6	10	15	20
Full-load efficiency (per cent.)	55	64	68	72	76	80	82	83
Half ,, ,, ,,	42	53	56	60	65	69	72	73
Full-load watt-consumption	270	860	2,160	3,600	5,800	9,200	13,500	17,800
Half ,, ,, ,,	170	520	1,300	2,150	3,400	5,700	7,700	10,000
Full-load power-factor (per cent.)	65	68	72	73	75	80	80	82
Half ,, ,, ,,	48	51	55	56	60	62	62	64
Amperes at start } At 110 volts.	7·5	18	38	50	65	90	120	145
,, full load } At 110 volts.	3·8	11	27	45	70	105	154	200
Revs. per min., running light	1,500	1,500	1,500	1,500	1,500	1,500	1,000	1,000
,, ,, fully loaded	1,350	1,390	1,400	1,430	1,430	1,430	965	965

W. G. R.

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712. *Starting Non-Synchronous Single-Phase Motors.* **R. Arno.** (L'Elettricista, Rome, 6. 11. pp. 265–269, and 7. 5. pp. 97–98, 1898.)—The author shows that, with a suitable resistance in the armature circuit, a single-phase motor can be started by giving a very small initial velocity to the armature, such in fact as can be given by a pull on the belt by hand. Once started, the resistance can be gradually cut out. This method of starting does away with the necessity of two windings on the inductor and means for

producing a difference of phase between the two (see Abstract No. 77).

The author, in his second paper, describes a method of giving the initial starting-pull to the motor by electrical means only. The method is to produce a dissymmetry in the armature at the moment of starting by opening the circuit of one of its windings. Then, provided the armature is not at a dead-point, it will rotate through a portion of a turn, and, if the circuit be then closed, this rotation provides a sufficient impulse to enable the motor to get up speed. Supposing the armature to have a three-phase winding, a three-arm resistance-switch is inserted in the three circuits, the full resistance being the best starting resistance mentioned above. Two circuits are closed through the resistances; the third is brought to one pole of a two-pole switch, the other pole of which is in the field circuit. The switch is so arranged as to first close only the field circuit, thus giving an initial rotation to the armature; a further movement of the switch closes the armature circuit and enables the motor to get up speed. The best conditions for starting are obtained by cutting all outside resistance out of the armature circuit, putting it in immediately the circuits are closed. The armature can be moved from a position of dead-point by means of a switch in one of the other circuits; if the double-pole switch be closed, leaving this switch open, the armature will rotate to a dead-point corresponding to this position of dissymmetry. On breaking the circuit and closing the single-pole switch, the position of dissymmetry is changed, and the motor is no longer at a dead-point. The direction in which the motor starts is determined by the circuit in which the single-pole switch is placed.

G. H. BA.

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713. *Separation of Iron Losses of a Transformer.* **H. S. Carhart.** (Elect. World, 31. p. 306, 1898.)—If the frequency of the voltage applied between the primary terminals of a transformer is varied while the induction in the core is kept constant, then the total iron losses W_1 may be written

$$W_1 = an_1^2 + bn_1, \quad \dots\dots\dots \quad (1)$$

where a and b are constants and n_1 is the frequency.

If the frequency is changed to n_2, we get

$$W_2 = an_2^2 + bn_2. \quad \dots\dots\dots \quad (2)$$

Solving equations (1) and (2) we get the values of a and b, which are respectively the eddy-current loss and hysteresis loss per cycle for the same maximum induction. W_1 and W_2 are determined by taking wattmeter readings on open secondary circuit.

The author applies this method to an actual case, and also calculates the value of the exponent k in Steinmetz's formula

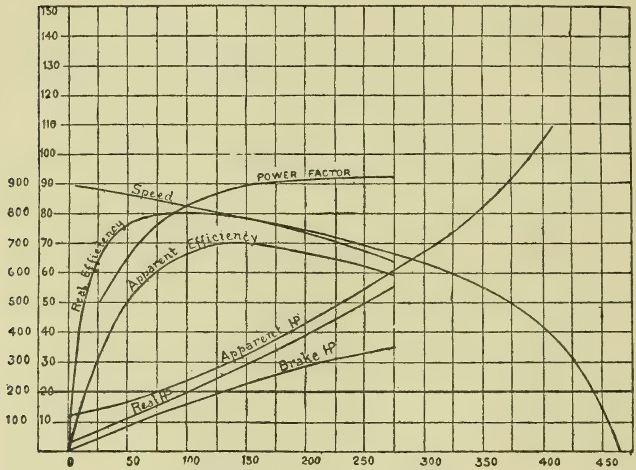
$$W = \eta n B^k$$

for hysteresis loss.

W. G. R.

714. *Practical Operation of Multiphase Currents.* **T. Hawkins.** (Elect. Rev. 42. pp. 421–422, 456–457, & 489–490, 1898.)—This is a paper read before the Northern Society of Electrical Engineers. The chief features of interest are the illustrations and curves, two of which are here reproduced.

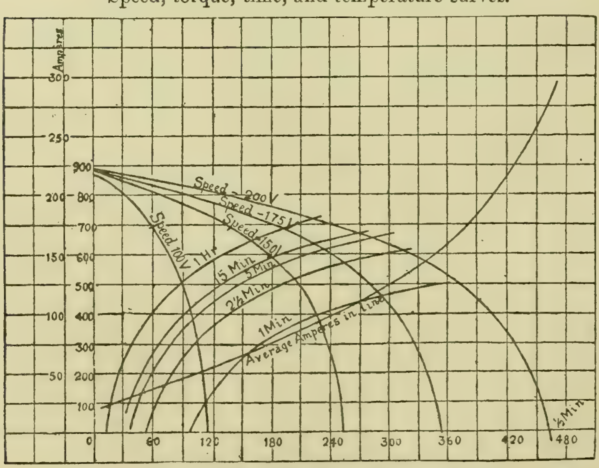
Fig. 1.—Polyphase Crane Motor, two-phase, 7,200 alts. 8-pole, 200 volts.



Pounds torque at 1 foot radius.
Rise in temperature for 8 hours' run at 20 H.P. Output, 200 volts; primary, 20° C.; secondary, 20° C.

Fig. 2.—Polyphase Crane Motor, two-phase, 7,200 alts., 8-pole, 200 volts.

Speed, torque, time, and temperature curves.



Pounds torque at 1 foot radius. W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

715. *Comparative Cost of Steam-Power and Electrically Transmitted Water-Power.* **C. Saldini.** (Elettricità, Milan, 17. pp. 53–56, 1898.)—The author deals with the following costs :—(1) The annual cost of a B.H.P. produced by a steam-engine. (2) The capital cost of a B.H.P. produced by water-power, considered first at the turbine-shaft and secondly at the receiving station of an electric transmission line. (3) The annual cost of a B.H.P. in the two cases considered in (2).

Table I. gives the total annual cost of a B.H.P. produced by a steam-engine, and the various items making up the total. For engines above 500 H.P. the cost per unit is assumed constant. Coal is taken at 20 shillings a ton. Working hours per annum, 3300. Interest on capital outlay taken at 5 %. Amortisation taken at 3 % on buildings, and 5 % on machinery and boilers. Repairs not allowed for. Prices given in pounds and decimals.

The capital cost per B.H.P. of a water-power plant is from £21 to £23, and the annual cost of running from 34 to 38 shillings. Including the electrical plant, the capital cost under ordinary conditions for large powers is from £26·5 to £30 at the turbine shaft, and from £42 to £50 at the receiving station, the latter figure not including distribution expenses. For a plant of 10,000 to 12,000 H.P., assuming the lower figure, the cost is made up as follows :—

	£
Projects, Concessions, Formation of Company and General ...	3·8
Hydraulic works and Buildings	15·2
Turbines, Tubing, Gates, etc.	3·8
Alternators, Exciters, Switchboards, Crane, Reserves, etc.	7·6
Transmission-lines, Indemnities, Poles, Copper, and Accessories, Buildings of Receiving Station, Transformers, etc.	11·6
Total............	42 0

The running expenses are calculated as follows :—

		shillings.
Amortisation on 1st of the above items	at 1·5 % ...	1·15
„ 2nd „ „	„ 1·5 „ ...	4·56
„ 3rd „ „	„ 5 „ ...	3·80
„ 4th „ „	„ 6 „ ...	9·10
„ 5th „ „	„ 3 „ ...	6·84
Maintenance and Repairs of Machinery and Line	„ 1·5 „ ...	6·84
„ „ Canal and Buildings	„ 1 „ ...	3·04
Management and Administration		7·00
Water-rights and Taxes		6·50
Sundries		9·18
		58·00
Interest at 5 % on £42		42·00
Total		100·00

This figure the author considers more as a minimum than as an average value.

On a similar basis is calculated Table II., giving the comparative cost for a year of 3300 working hours of steam-power and electric power at the receiving station. From this table it is seen that electric power has an advantage in economy only for the smaller motors, up to about 60 H.P. The author observes, however, that the working day of 9 hours can be increased in the case of electric power without appreciably increasing the annual cost per B.H.P.

[The costs given above for wages and management are based on prices holding in Italy, and should be doubled to conform to English prices. The item "Water rights and taxes" includes the Government tax of *2s. 8d.* per annum per H.P. and the tax of 15 % on the profits.]

TABLE I.

H.P. of Engine.	Cost of Cardiff Coal per B.H.P.	Wages, Oil, etc.	Working Costs per B.H.P.	Interest on Capital.	Amortisation of Capital.	Total Cost per B.H.P.
1	11·3	32·3	43·6	3·8	3·8	51·2
3	10·4	13·5	23·9	1·9	2·8	28·6
8	8·5	5·7	14·2	1·7	2·1	18·0
15	7·4	3·2	10·6	1·45	1·8	13·8
25	6·5	2·3	8·8	1·35	1·7	11·8
40	5·25	1·7	6·95	1·20	1·65	9·8
60	4·50	1·35	5·85	1·15	1·50	8·5
90	4·00	1·15	5·15	0·95	1·30	7·4
150	3·55	0·95	4·50	0·85	1·20	6·5
200	3·25	0·75	4·00	1·95		6·0
250	3·00	0·70	3·70	1·90		5·6
300	2·85	0·65	3·50	1·80		5·3
400	2·65	0·60	3·25	1·70		5·0
500	2·55	0·55	3·10	1·70		4·8

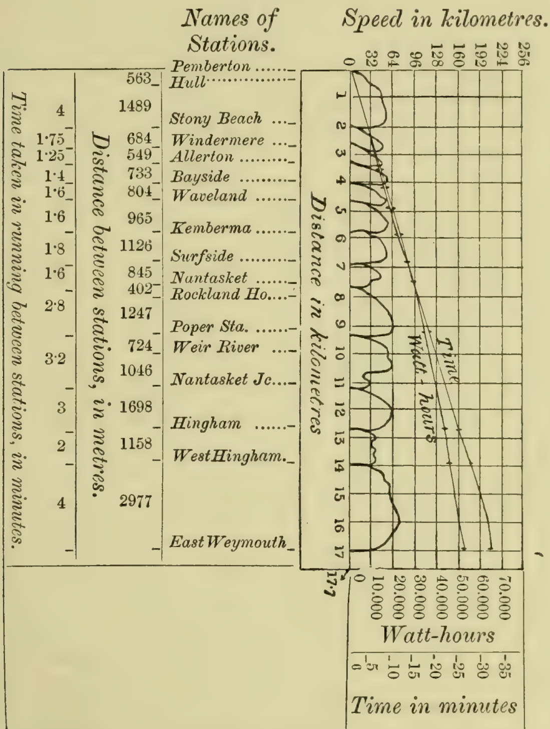
TABLE II.

H.P. of Engine.	Annual Cost per B.H.P. Steam. Pounds.	Annual Cost per B.H.P. Electricity. Pounds.	Difference. Pounds.	Cost per kilowatt-hour. Steam. Pence.	Cost per kilowatt-hour. Electricity. Pence.
1	51·2	22·8	28·4	5·07	2·26
3	28·6	17·9	10·7	2·83	1·77
8	18·0	15·2	2·8	1·78	1·51
15	13·8	13·3	0·5	1·37	1·32
25	11·8	11·4	0·4	1·17	1·13
40	9·8	9·5	0·3	0·97	0·94
60	8·5	8·4	0·1	0·84	0·83
90	7·4	7·6	−0·2	0·73	0·75
150	6·5	6·9	−0·4	0·64	0·68
200	6·0	6 4	−0·4	0·59	0·63
250	5·6	6·0	−0·4	0·56	0 60
300	5·3	5·8	−0·5	0·53	0·58
400	5·0	5·5	−0·5	0·50	0·55
500	4·8	5·3	−0·5	0·48	0·53

G. H. BA.

716. *Electric Railways.* **G. Pellissier.** (Écl. Électr. 14. pp. 273–278, 335–339, 367–370, 1898.)—The author first considers the competition between railways and tramways, and the maximum distance which is permissible between stations in order that a railway should retain its traffic when there is a competing tramway. Some account is then given of the Nantasket Beach and Hartford lines (see Abstract No. 218). The importance of high acceleration is pointed out. On the Nantasket Beach line, the distance of 17 km. (10·6 miles) is run at an average speed of 40 km. (25 miles) per hour, including the 16 stops. The speed between stations is graphically shown in Fig. 1, which is reproduced, and refers to a

Fig. 1.

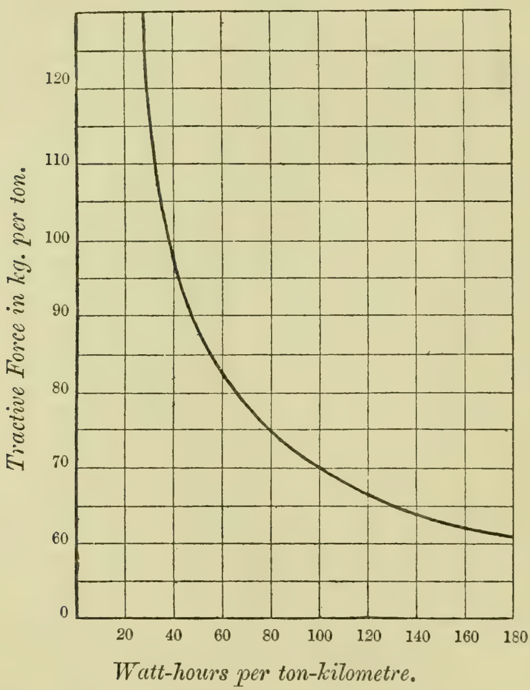


train 56·3 tons in weight. Between Windermere and Allerton, a distance of only 500 metres (550 yds.), the speed rose to 50 km. (31 miles) per hour. The power amounted to 52·1 watts per ton. In the case of a train of 31 tons, the maximum speed of 65 km. ($40\frac{1}{2}$ miles) per hour was attained at the end of 67 seconds from the start, the energy expended amounting to 90 watt-hours per ton. On the New Britain and Hartford line the ordinary trains,

consisting of a motor car and two trailers, reach a mean speed of 45 to 50 km. (28 to 31 miles) per hour, and special trains a mean speed of 90 km. (56 miles). In the experiments made for the Illinois Central Company, a car of 25 tons carrying 18 people and equipped with four G.E. 50 H.P. motors, attained a speed of 66 km. (41 miles) per hour in 20 seconds, but the power required appears excessive. A table is given showing the tractive force, acceleration, etc. of some steam and electric railways in the United States.

In the second part of these papers the author considers the economy to be effected by the use of high acceleration. The curve in Fig. 2 gives the relation between tractive effort employed in

Fig. 2.



acceleration and the expenditure of watt-hours per ton-kilometre, supposing the run between two stations to consist in uniform acceleration, drifting, and braking (see remarks by Steinmetz, Abstract No. 346). The most economical acceleration to adopt must depend upon the conditions in each particular case. The increased expense of high speed is to a large extent balanced by the decrease in rolling-stock, power, station, and staff for the same service, and by the increase of traffic which always results.

The third contribution refers to the high-speed traction scheme suggested by C. H. Davis and F. S. Williamson (see Abstract No. 340). W. R. C.

717. *Economics of Central Station Working.* **C. P. Feldmann.** (Écl. Électr. 14. pp. 427–430 & 475–477, 1898.)—In this paper the efficiencies of the various transformations of energy in transit from the coal to the lamps are discussed in detail, with the aid of diagrams, and the conclusion is arrived at that the most promising opening for improvement is in the efficiency of the lamps. Tables based on stated assumptions are given, showing the amount of coal consumed, the fixed and operating expenses, and the corresponding selling price, per kilowatt-hour, with load factors varying from 5·7 to 68·5 per cent.; the price ranges from 10*d.* per kilowatt-hour in the former case, to 1*d.* in the latter. The price of supply for electric traction is also considered, and is estimated at 1*d.* per kilowatt-hour with a load factor of 34·25 per cent. The possibility of improving the load factor by the application of electricity to heating and chemistry, and by the use of special systems of charging for electrical energy, is discussed, and the method of charging adopted at Rheinfelden is described in detail. A. H. A.

718. *Difficulties in Heavy Electric Traction.* **L. Bell.** (Elect. World, 31. pp. 23–25 & 67–68, 1898.)—The author points out that the possibility of working long railways electrically more economically than with steam locomotives depends rather upon the efficiency of line and motors than upon the reduction of the coal bill. The case is considered of working an actual line which now employs 665 steam locomotives on a road of about 1700 miles in length. Even assuming high-tension alternating current to be delivered direct to the locomotives, the result shows that there would be practically no gain in economy. With dense traffic in compact suburban districts the case is very different. One disadvantage in electric traction is the serious danger of a general breakdown of the system from a single accident. With regard to line efficiency, there would be a decided gain in all except the shortest lines by employing a pressure of 750 volts in place of the usual 500 to 600 volts. Motors could be made to work as satisfactorily as with the lower pressure. Another difficulty is experienced in the selection of a suitable conductor. A trolley-wheel is unsatisfactory for heavy work or high speed, and a third rail is troublesome at crossings. W. R. C.

719. *Central London Railway.* (Engineering, 65. pp. 214–216, p. 236, pp. 259–263, & pp. 329–331, 1898.)—On pages 214–216 is given the history of the development of Underground Railways in London, with a brief reference to the different projects for rapid transit in London. Then follows a statement of

the inception and development of the Central London Railway together with a schedule of the proposed service. A map of the route with the stations marked thereon is given.

Page 236 contains complete description of locomotive and particulars of the electrical equipment and also method of bonding track rails and description of third rail, with illustrations of locomotive, motors, controllers; third rail and curves of speed and torque of the motors.

Pages 259–263 contain description of generating station and plant. A diagram of the losses and constants pertaining to the system, comparison of the losses for a supply on the three-wire system and on the three-phase system which was finally adopted, curves for the speed over part of the route for a given average speed, and a statement of losses and efficiencies of the Power plant. The article contains illustrations of the three-phase generators, rotary converters, and transformers and H.T. switch.

Pages 329–331. This article deals with the methods of construction of the tunnel, and the nature of the work and the strata passed through, with an illustration of the machinery employed.

H. F. P.

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720. *Testing Railway Circuits.* **S. F. Jeter.** (Street Rly. Journ. 14. p. 135, 1898.)—The author proposes the use of an auxiliary test wire to be connected with the trolley wire and ground at some distant place, and connected with a voltmeter at the generating station. The other voltmeter terminal being connected successively with the line and earth, the drop of volts can be determined both along the line and through earth.

W. G. R.

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721. *Trucks for Double Deck Cars.* (Street Rly. Journ. 14. pp. 57–58, 1898.)—The use of double deck cars, as in England, increases the difficulties as to oscillation, owing to the fact that the centre of gravity is raised 30 ins., bringing it to about 7 feet above the track. No trouble would arise with a long spring base together with a 7 ft. wheel base. But in European practice a wheel base of 5 ft. 6 ins. or 6 ft. is usual, and therefore the Peckham Truck Company have resorted to the counterweight principle of balancing the weight of the car, when it tends to oscillate, by that of the motors, wheels, axles, and side-frames. This is effected by the use of springs in tension placed below the usual end-springs that are in compression. The cars at Leeds, Dublin, and elsewhere are constructed on this principle. W. R. C.

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722. *Electric Railway Feeders.* **G. T. Hanchett.** (Amer. Electn. 10. pp. 104–105, 1898.)—The author attempts to formulate working rules for the calculations concerning railway feeders. Rails are usually designated by their weight in pounds per yard. If w is this weight, then the weight in tons per mile is $0{\cdot}88\,w$.

Rails are usually supplied in 60-ft. lengths, so that there are 88 rails and 88 bonds to the mile.

The following table will assist in estimating the cost of bonding:

SIZE AND COST OF COPPER BONDS.

Weight of Rail. Pounds per yard.	Equivalent Copper Bond. Circular mils.	Cost of Equivalent Bond.
5	90,909	$0·39
10	181,800	0·59
15	272,700	0·83
20	363,600	1·04
25	454,500	1·27
30	545,400	1·51
35	636,300	1·73
40	727,200	1·97
45	818,100	2·20
50	910,000	2·43
55	1,000,000	2·65
60	1,091,000	2·88
65	1,182,000	3·12
70	1,275,000	3·36
75	1,364,000	3·59
80	1,455,000	3·82
85	1,546,000	4·05
90	1,637,000	4·28
95	1,727,000	4·54
100	1,819,000	4·78
105	1,909,000	4·92
110	2,000,000	5·19

A 55-lb. rail is electrically equivalent to one million circular mils. Therefore, if we have a rail of weight w, divide this by 55, and multiply the result by one million, we get the equivalent copper cable for that rail. Also a foot of rail will carry an amperage equal to one hundred thousand times its weight per yard with a drop of 55 volts. If this current is divided by the number of feet over which current is to be transmitted, we get the current the rail will carry for that distance with a drop of 55 volts. Since this is quite a usual drop of volts these rules may be applied.

W. G. R.

723. *Train Resistance.* (Engineer, 85. p. 151, 1898.)—Tractometer experiments seem to indicate that the resistance of a train increases with the speed. On the other hand, indicator diagrams taken at high speeds invariably show a lower mean effective pressure than diagrams taken at lower speeds; thus apparently showing that the total resistance of engine, tender, and train diminishes as the speed increases. A. S.

724. *Engines for Electric Traction.* **C. E. Emery.** (Street Rly. Journ. 14. pp. 23–36, 1898.)—A former paper (Street Rly. Journ. Oct. 1897) treated of large cross-compound Corliss engines; the present paper deals with "intermediate speed engines," running at 100–200 revs. per min. The engines described are the "Porter-Allen," the "Buckeye," the "Brooklyn-Edison," made by McIntosh, Seymour & Co., and the "Paterson" made by the Ball & Wood Co. In the Porter-Allen engine the distribution of steam in each cylinder is effected by four independent flat-balanced slide-valves; in the "Buckeye" engine piston-valves are used; in the "Brooklyn-Edison" four gridiron valves are used on each cylinder, the travel of the valves being across the cylinder; while in the "Paterson" engines four valves of the Corliss type are used, the steam and exhaust ports being placed in the cylinder covers. The governors and valve-gears are fully described. A. S.

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725. *Steam-Storage Motor Tram-Car.* (Railway World, 7. pp. 43–45, 1898.)—The car is equipped with a small engine, a hot-water boiler or reservoir, and an air-condenser. Water is heated at the central station to a temperature of 380° F., corresponding to a pressure of 200 lbs. per sq. in., and is transferred to the boiler underneath the car body. To compensate for loss of heat by radiation, a small fire-box is provided and a pan of red-hot anthracite coal is introduced when the boiler is charged. The heat from the coal is ample to maintain the pressure for the longest trip required in practice. The air-condenser consists of a pair of steel headers, the inner faces of which are connected by 3-in. tubes, the outer faces by 2-in. corrugated tubes, leaving an annular space ½ in. wide for the exhaust steam. Speeds of 12 to 30 miles an hour are reported, and runs of 20 miles with one charging. The weight complete is 28,000 lbs. A. S.

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726. *Lachmann Conduit System.* **Svilokossitch.** (Électricien, 14. pp. 331–332, 1897.)—This is an illustrated description of the Lachmann System for Electric Tramways, in which the conductors are laid in conduits so constructed that they are kept perfectly dry even if the tramway is inundated. The conduits are placed at a depth of about 15 centimetres. W. G. R.

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727. *Car-Wheel Grinder.* (Street Rly. Journ. 14. p. 57, 1898.)—A machine is described for grinding worn car-wheels, so as to reduce them to an efficient working condition. It is made by the Hampden Corundum Wheel Company. W. R. C.

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728. *Rail Bonding.* **H. P. Brown.** (Elect. World, 31. pp. 28–30 & 65–66, 1898.)—The author gives an historical account of rail-bonding. W. R. C.

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729. *Bryan Bond.* (Street Rly. Journ. 14. p. 58, 1898.)—This bond appears to be giving a good deal of satisfaction. The Consolidated Traction Company report a large saving in the return

circuit by its use, amounting in some cases to 20 per cent. The bond consists of two wires held by grooved washers. Against the rail is first placed a thin corrugated copper washer, then a grooved copper washer, and lastly a grooved steel washer, the three being held firmly in position by a bolt passing through the web and well screwed up. W. R. C.

730. *Constant-Current Acceleration Controller.* (Elect. World, 31. pp. 385–386, 1898.)—The object of this controller, due to S. H. Short, is to maintain the current in starting a car practically constant, and thus obtain uniform acceleration. There are seven notches. The first three cut out successive portions of a dead resistance; the three following short-circuit parts of the field-winding; the seventh replaces the whole field in circuit, the car having then reached its normal speed. After the first notch the action is automatic, and thus does not depend on the motor-man. This method depends upon a considerable field-commutation, and therefore ample magnetic cross-section. The motor must also be made with a greater margin of available power, in order to avoid great distortion of the field with a reduced number of field-turns; it must therefore be heavier than is required with ordinary control. A further objection to the method is that light cars will start much more rapidly than those that are heavily loaded. W. R. C.

731. *Storage Batteries in Traction-Stations.* (Street Rly. Journ. 14. pp. 1–3, 1898.)—An account is given of the advantages experienced at Pittsburgh by the use of a battery at one of the power-stations. W. R. C.

732. *Cost of Electrical Energy.* (Elect. Rev. 42. p. 239, 1898.) —Some figures are given, due to Shallcross, bearing upon the price which should be charged by electric lighting companies supplying energy to traction systems. The estimate goes to show that $1\frac{1}{4}d.$ per unit is a profitable price in the case of a 15,000 H.P. plant working 18 hours per day at a little less than half-load, if it produced 2,000,000 units per annum. An estimate is also given in the case of working at full-load. W. R. C.

733. *Enclosed Arc Lamps.* **J. H. Hallberg.** (West. Electn. 22. p. 175, 1898.)—This paper gives the results of experience with enclosed arc-lamps, and in addition to a large amount of detailed information on the construction and working of these lamps, advocates the use of high-tension enclosed arc-lamps in cases where larger units are required. C. K. F.

734. *Vacuum-Tube Lighting.* **N. Tesla.** (Elect. Rev. N. Y. 32. pp. 8–9, 1898.)—Some photographs taken by means of a 1000 c.p. vacuum-tube are reproduced. No quantitative results are given. W. R. C.

TELEGRAPHY AND TELEPHONY.

735. *Hertz Telegraphy.* **K. Strecker.** (Electrician, 40. p. 791, 1898.)—This is an abstract of a paper read before the Elekt. Verein, 22nd February, 1898. When Morse signals are to be transmitted by means of a Hertz oscillator and a coherer, the spacing and duration of dots and dashes are not of cardinal importance. If, however, a Hughes instrument is to be employed, the succession of current-impulses must be very carefully timed. Synchronism is possible only at comparatively low speeds. The author therefore concludes that for Hertz telegraphy the Hughes instrument has no advantages over the Morse. A diagram shows the method of applying the Delany closed-circuit relay system at a receiving station between the coherer and a Morse instrument; the effect of this relay is to interpose inertia, and thus to shorten the dots and dashes. R. A.

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736. *Telephone Finance.* **J. J. Nate.** (West. Electn. 22. pp. 159–160 & p. 174, 1898.)—These two articles give a condensed account of the present financial situation of telephone-working in America. The conditions that determine the cost of maintenance are carefully discussed, the equipment of exchanges both as regards apparatus and staff is considered, and figures are given as to the rate of earning of a telephone system, making due allowance for rentals and reconstructions. Some idea is given of the progress made in toll-lines in the United States; and here the author calls attention to the serious losses incurred through lack of uniformity in the telephone apparatus. The apparatus at one exchange may be quite unsuited for efficient service over the lines or throughout the system of a neighbouring exchange; this condition is often due to the purchase of cheap and inferior material for small exchanges, which is altogether inadequate for toll-line service. A well-equipped and well-operated telephone exchange in America is generally able to show a profit of 20 per cent. *net* on the total capital. R. A.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JULY 1898.

GENERAL PHYSICS.

737. *Vortex Motion.* Part III. **W. M. Hicks.** (Roy. Soc. Proc. 62. pp. 332–338, 1898.)—The writer describes a new system of spiral vortices. Suppose an infinitely long cylindrical vortex of sectional radius a, with internal velocity perpendicular to the axis $v=f(r)$, where $f(0)=0$. Externally, $v=\mathrm{V}\frac{a}{r}$ and $\mathrm{V}=f(a)$. Again, suppose a motion parallel to the axis inside, the fluid being at rest outside. The velocity will then be internally $u=\mathrm{F}(r)$, with $\mathrm{F}(a)=0$, and externally zero. The two motions superposed lead to steady motion with vortex filaments in the shape of helices lying on concentric cylindrical surfaces. The writer's problem is to conceive a similar superposition of two motions in the case of any vortex aggregate symmetrical about an axis.

For a particular case of spherical aggregate it is found that the motion in meridian planes is determined by a function ψ, the differential equation of which is

$$\frac{d^2\psi}{dr^2}+\frac{1}{r^2}\frac{d^2\psi}{d\theta^2}-\frac{\cot\theta}{r^2}\frac{d\psi}{d\theta}=\rho^2\mathrm{F}-f\frac{df}{d\psi},$$

where F and f are functions of ψ.

In a particular case fully treated, in which F is uniform and $f=\lambda\frac{\psi}{a}$,

$$\psi=\mathrm{A}\left\{\mathrm{J}_2\left(\frac{\lambda r}{a}\right)-\frac{r^2}{a^2}\mathrm{J}(\lambda)\right\}\sin^2\theta.$$

As λ increases we get a periodic system of families of aggregates differing from one another in the number of layers and equatorial axes they possess. The properties of these families are discussed.

The writer further considers the question whether the theory throws any light on the vortex atom theory of matter. It is pointed out, firstly, that the quantitative theory developed in the paper assumes a surrounding irrotational ether, which cannot be the case in nature; secondly, that the results refer only to spherical aggregates—that is, to an artificial assumption. Nevertheless some general conclusions are drawn as highly probable: *e. g.*, that the metals belong to aggregates having an even number of layers or axes, *i. e.*, as shown, the outer rotational motion is opposite to that of the centre. It is found also that the moment of momentum due to the gyrostatic effect rises and falls with the volume of the atom. S. H. B.

738. *Mathematical Theory of the Top.* **Carl Barus.** (Science, 7. pp. 469–474, 1898.)—This is a review, by Barus of F. Klein's four lectures. According to Barus, Lecture I. introduces four new parameters, as follows:—The top is first supposed to spin on a fixed point of support. Let $x\,y\,z$ and X Y Z be points on a fixed and a movable sphere respectively, each of radius r and in congruence. Then, if

$$\zeta = \frac{x+iy}{r-z} = \frac{r+z}{x-iy} \quad \text{and} \quad Z' = \frac{X+iY}{r-Z} = \frac{r+Z}{X-iY},$$

ζ and Z are two parameters, each of which determines a point on the fixed or movable sphere. The relation between ζ and Z' is then

$$\zeta = \frac{\alpha Z'+\beta}{\gamma Z'+\delta} \quad \text{and} \quad \alpha\delta-\beta\gamma = 1.$$

The four new parameters are α, β, γ, δ. The Eulerian coordinates ϕ, ψ are expressed in terms of these parameters. Then the Z pole of the moving sphere is selected, at which $Z=\infty$, and at this point $\zeta=\alpha/\gamma$. Hence ζ is at once expressible as a single quotient of single-valued σ functions with an exponential time-factor. Thus is effected a great simplification of the problem.

The rolling and fixed cones, or polhode and herpolhode, are then investigated. It is shown how a free body in hyperbolic non-Euclidean space may be so fashioned in real time as to carry out the actual motion of the top.

In the fourth lecture the restriction that the top shall spin on a fixed point of support is removed. S. H. B.

739. *Principle of Physical Development.* **O. Wiedeburg.** (Annal. Phys. Chem. 63. 1. pp. 154–159, 1897.)—The author shows that complete cyclical processes are not possible in bodies covered by his fundamental equations. It never happens that all the conditions of a solid body revert to the same point at the same time; they are, so to speak, displaced with respect to each other. The body as a whole, as far as its quantitative conditions are concerned,

is ever a new one. It "ages," and never returns altogether to its previous state. Such irreversible processes probably occur also in liquids and gases. E. E. F.

740. *Relative Motion of the Earth and Ether.* **W. Sutherland.** (Phil. Mag. 45. pp. 23–31, 1898.)—In the experiment of Michelson and Morley a beam of light is split into two parts, which, after travelling backwards and forwards along equal paths at right angles, return to the parting place in such a condition as to produce interference-fringes. If the earth is moving relatively to the ether, and one of the paths is in the direction of the relative velocity v, while the other is at right angles to it, then, if V is the velocity of light and 2D the distance travelled by the beams between parting and meeting again, the actual paths, instead of being equal, differ by Dv^2/V^2. If now the whole optical apparatus is turned through a right angle the same difference accrues, but in the opposite way, so that the total difference obtainable by contrasting the two cases is $2Dv^2/V^2$, and ought to produce a corresponding displacement of the interference-fringes as seen in the two positions of the apparatus. Michelson and Morley aimed at making their optical adjustments so sensitive that the alteration in the fringes would be definitely measurable, although when v is equal to the earth's velocity in its orbit v^2/V^2 is as small as 10^{-8}. The result of their measurements was to make it appear as if $v=0$, that is to say, that the earth carries the ether with it: a dilemma for physicists. The author urges that there is one assumption in the theory of the optical part of the experiment which has not been provided for in the actual arrangements; namely, that the line which is common to the two wave-fronts of the divided beam when the two meet again is of identical origin in each wave-front, that is to say, that one line in the wave-front before division has the said common line as its representative in both wave-fronts. It is pointed out that under the experimental conditions a lateral shift of the one front relatively to the other can occur; and though minute, may still be large enough to make the optical apparatus much less sensitive than it was supposed to be. In this case the experiment, instead of proving that $v=0$, may only prove that the apparatus had not been made of the order of sensitiveness to measure the minute v^2/V^2. To get the sensitiveness up to the Michelson and Morley ideal, it will be necessary to make the lateral shift small enough or to get the axis of symmetry of the fringe system into the field of view, either of which may prove a tedious adjustment to realise practically. AUTHOR.

741. *Diameter of Venus.* **K. Strehl.** (Zeitschr. Instrumentenk. 18. pp. 43–49, 1898.)—The paper deals with the observed differences in the diameter of the planet, first, when measured in the ordinary way, the disc of the planet being bright on the darker sky, and second, when measured during a transit

of the planet across the sun, when it appears as a black spot on the bright photosphere. Both halation and diffraction affect the measures, and these quantities are very different in the two cases. C. P. B.

742. *Viscosity of Solids.* **A. Heydweiller.** (Annal. Phys. Chem. 63. 1. pp. 56–60, 1897.)—The viscosity of menthol was determined in the solid and liquid states to obtain some information on the changes which this property undergoes with rise of temperature and change of state. The method adopted for the solid state consisted in blocking a glass tube with a plug of the solid menthol, and measuring the rate of displacement due to a difference of pressures on the two sides. The tube on one side of the plug was connected to a vertical tube of finer bore, and all the space on that side of the plug, including the vertical tube, was filled with mercury. The space on the other side of the plug was evacuated. The rate of displacement of the menthol was registered by the rate of fall of mercury in the vertical tube.

The curve showing the variation of viscosity with temperature consists of two parts—that for the solid, and that for the liquid conditions. Both parts are approximately straight. The temperature-coefficient for the solid state is very great, amounting to 20 %. The viscosity in the solid state is 10^{11} times that in the liquid state. J. B. H.

743. *Apparatus for Constant-Temperature Water-Current.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 18. pp. 49–52, 1898.)—Water, taken from the supply-pipes, is first brought to a pressure-regulator consisting of a cistern with overflow-pipe, the supply being so regulated that there is always a small overflow. It is then led through a copper heating spiral, $3\frac{1}{2}$ metres long, coiled between two vertical metal cylinders, open below and closed above. A Bunsen burner is placed under the inner cylinder, the hot gases issuing through holes at the top and descending between the cylinders. The hot water, after doing its work, is led to a second cistern with an overflow-pipe for discharge. To avoid air-bubbles collecting, the water should flow upwards in the heating spiral and in the succeeding tubes. A gas regulator is not necessary, unless there be considerable variations in the pressure of the gas-supply. The author claims that this apparatus will maintain a constant temperature for an hour within a few tenths of a degree. A fine adjustment of the temperature is made by varying the difference of level between the two cisterns.

G. H. Ba.

744. *Constant Temperature Device.* **K. P. Cady.** (Journ. Phys. Chem. 2. pp. 242–244, 1898.)—Illustrated description of an apparatus for large operations, worked by a turbine. S. G. R.

745. *New Integraph.* **A. H. Barker.** (Mech. Eng. 1. pp. 304–305, 1898.)—A frame mounted on three wheels, to run from left to right, carries two pencil carriages which run up and down. The upper carriage carries the integrating wheel, which rolls on the paper. The lower carriage carries a tracing-point P, which is moved over the curve to be integrated. A tangent-bar is arranged so that the tangent of its angle of inclination is proportional to the ordinate to P. The plane of the integrating wheel is always kept parallel to the tangent-bar. If the tracing-point P move over a curve $y=f(x)$, a pencil Q attached to the upper carriage will trace out the curve

$$y = \int f(x)\, dx.$$

A. S.

LIGHT.

746. *Analogy between Pendulum Motion and Light.* **E. Ketteler.** (Annal. Phys. Chem. 63. 1. pp. 72–77, 1897.)—This is a mathematical paper, showing an analogy between the equations of motion of a vibrating pendulum left to itself under certain damping forces and the passage of light into a transparent medium. In a transparent medium with increasing angle of incidence a similar discontinuity occurs for the light vibrations as occurs for the oscillations of the pendulum by increase of the damping coefficient. J. B. H.

747. *Optical Constants of Sodium.* **P. Drude.** (Annal. Phys. Chem. 64. 1. pp. 159–162, 1898.)—The refractive index n and the index of absorption κ were measured by the method of reflection, the sodium being enclosed in a glass cell containing an atmosphere of hydrogen. The apparatus used was the same as in a former investigation by the author (Annal. Phys. Chem. 39. p. 381, 1890). The values obtained for sodium with sodium light are

$$n\kappa=2{\cdot}61\,; \qquad n=0{\cdot}0045\,; \qquad \kappa=580.$$

From the value of n it appears that the velocity of light in sodium is 220 times greater than in air. The author thinks the errors of observation might allow the value of n to be as high as 0·054, which is still the smallest refractive index known, the next being sodium-potassium alloy and the next again being silver ($n=0{\cdot}18$).
J. B. H.

748. *Optical Properties of Hydrophane.* **J. Stscheglayew.** (Annal. Phys. Chem. 64. 2. pp. 325–332, 1898.)—Hydrophane is a whitish mineral resembling opal. It is capable of absorbing liquids, and thereby becoming perfectly transparent. In doing so, its refractive index changes, and it is found to be such as would result if two liquids, having the refractive indices of hydrophane and the liquid experimented with, had been mixed together in the same proportions. Hence the solid body behaves in this case like a liquid, and its refractive index may be found by mixing two liquids of known refractive indices until their joint index equals that of the moistened hydrophane. Such a mixture is that of 29 per cent. of toluol and 71 per cent. of alcohol, with a refractive index of 1·46. E. E. F

749. *Lambert's Law.* **F. Koláček.** (Annal. Phys. Chem. 64. 2. pp. 398–408, 1898.)—The author compares his own theory of diffused reflection with that of Uljanin, which is based upon Kirchhoff's theory. The latter is founded upon the two laws of thermodynamics and upon the hypothesis that absolutely black bodies exist. But such black bodies do not exist, at least not when

they are to possess smooth surfaces. For even if the refractive index of the body with respect to the medium is unity, these bodies always reflect light to an extent proportional to their absorption and to the angle of incidence. For vertical incidence the reflection factor is $\sigma^2(4+\sigma^2)$, where σ is the refractive index. But it is not certain that the hypothesis of an absolutely black body is essential to the truth of Kirchhoff's theory. The author's theory is a purely optical one, but involves an hypothesis concerning the amplitude of the radiation inside a glowing body. It gives better results, with the best constants, than Uljanin obtains with his calculations. E. E. F.

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750. *Improvements in Telescopes.* **C. Devé.** (Comptes Rendus, 126. pp. 636–640, 1898.)—Certain arrangements and devices for the improvement of "autocollimating" telescopes are described; also modifications which enable the optical verification of the parallelism of portions of straight lines or planes to be carried out, even when the latter are not face to face, so that the ordinary methods cannot be applied. The arrangements can best be understood from the diagrams given by the author in the paper. J. J. S.

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751. *Index of Refraction of Compressed Gases.* **P. Carnazzi.** (N. Cimento, 6. pp. 385–400, 1897.)—The gases studied are air, hydrogen, and carbon dioxide. They are contained in a prism with glass sides. The prism is not placed on the table of a spectrometer, nor in the position of minimum deviation, but means are taken to determine the angle of the prism, the angle of incidence, and the angle of emergence. From these data, n, the index of refraction, can readily be calculated. A few typical results are given in the tables below. The second column in each table gives the value of n_0-1, the refractive power reduced to the *mean* temperature, and to the pressure of the first experiment. To effect this reduction the author employs the formula $(n_0-1)/\delta_0 =(n-1)/\delta_H$, δ_0 being the density of the gas under consideration in the conditions of the first experiment, and δ_H the density of the same gas at the temperature and pressure of the particular experiment. For Gladstone's law to be exact, $(n-1)/\delta_H$ should be a constant, and the values of n_0-1 should not vary for the same gas. With air and hydrogen the value of (n_0-1) increases with augmentation of pressure, whilst it decreases in the case of carbon dioxide.

Air.

Atmospheric Pressure 769·8 mm.	Mean temperature 12°·1.
Pressure in mm.	$(n_0-1)1000$
769·8	
5,264·74	0·31318
7,631·57	0·31842
10,527·79	0·32687
14,536·90	0·33554
37,627·82	0·36092

Hydrogen.

Atmospheric Pressure 770·4 mm.	Mean temperature 13°.
Pressure in mm.	$(n_0-1)1000$
770·4	
6,794·24	0·15753
11,714·7	0·17224
13,869·5	0·17225
20,296·2	0·18519
37,657·9	0·19127

Carbon dioxide.

Atmospheric Pressure 770·95 mm.	Mean temperature 13°·3.
Pressure in mm.	$(n_0-1)1000$
770·95	
1,696·14	0·44594
4,240·39	0·44155
7,309·59	0·43457
10,435·2	0·43184
19,779·2	0·4049

A. Gs.

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752. *Diffraction Phenomena in the Focal Plane of a Telescope.* **H. Nagaoka.** (Phil. Mag. 45. pp. 1–23, 1898.)—The author gives in the first place a general discussion of Fraunhofer's diffraction-phenomena of a circular aperture for a finite source of light, and shows how the intensity of illumination in the focal plane can be mechanically evaluated for a luminous source having any given shape. He then considers the intensity both inside and outside of a circular image. It is then shown how by the superposition of two systems of lines of equal intensity the formation of a ligament during the ingress or egress of a dark disc from a luminous source can be explained, as has been verified by the experiments of André and Angot. For practical purposes it is sometimes convenient to draw the lines of equal intensity. For a circular source of light they consist of a series of concentric circles, which if drawn for equal difference of intensity crowd together near the geometrical edge. When there are different sources of light the separate effects can be superposed and the distribution of illumination graphically represented in the following manner:—Draw the lines of equal intensity for the image of each source; at the point of intersection of any two lines the intensity will be the sum of the two. A system of points of equal intensity is thus obtained. By drawing the lines at small intervals a sufficient number of points can be found to draw curves of equal intensity,

which will represent the distribution of illumination due to different sources. In fact the process of drawing the lines of equal intensity is analogous to that of drawing equipotential lines. Suppose that the luminous source is a circular disc, on which there is a small dark circular space touching the rim of the disc. The image as seen through a telescope will form a drop, as the following consideration of the lines of equal intensity will show. Such a source may be imagined as produced by the superposition of two different sources, one of which consists of a circular disc of uniform intensity without any dark space, while the other consists of a circular disc occupying the place of the dark space, and of such intensity that it is equal but *of opposite sign*. This consideration immediately gives the solution of the problem either as mathematical formula or as graphical representation. For the latter purpose concentric circles are drawn representing lines of equal intensity for the luminous source, and similar lines of equal *negative* intensity for the imaginary source occupying the dark space; a series of lines of equal intensity due to these sources can thus be got. Diagrams are given by the author illustrating the case. From inspection of the figures it appears that when the dark space is in geometrical contact with the edge of a luminous source, it appears as a dark protuberance projecting from the surrounding dark space. With the receding of the dark space towards the interior of the luminous source, the connecting ligament becomes thinner, and finally disappears. The inner dark disc is, however, a little elongated, and assumes a pea-shaped appearance; while the external dark space bulges out towards the luminous source. The change is only transient; with further ingress the dark disc becomes circular, and the swelling of the external dark space vanishes. Thus to the first approximation the explanation of drop formation during the transit of inferior planets is arrived at. If the dark space be taken nearly equal to the luminous source and have small protuberances, by a similar process a result is obtained which has a close analogy with Baily's beads. J. J. S.

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753. *Artificial Temporary Colour-Blindness.* **George J. Burch.** (Roy. Soc. Proc. 63. pp. 35–38, 1898.)—The author describes how temporary blindness to light of a given colour is produced by exposing the eyes to light of that colour. When temporary colour-blindness has been induced to light of some particular colour, the other colours of the spectrum are surveyed, and the effects are described. Thus, when yellow blindness is induced and the spectrum viewed, the whole of the red and the whole of the green are affected. These experiments lead the author to the conclusion that no one colour-sensation is related to any other in the sense indicated by Hering. Each may be exhausted without affecting the others, and the observed facts are considered to be more in accordance with the Young-Helmholtz theory, but the existence of a fourth colour-sensation, namely, blue, is implied. T. P.

754. *Spectroscope without Prisms or Gratings.* **A. A. Michelson.** (Amer. Journ. Sci. 5. pp. 215–217, 1898.)—It is possible to construct gratings which shall throw a large proportion of the light in very high orders of spectra—say the hundredth—in which case the grating-space must be of the order of a hundred waves, or, say, twenty to the millimetre instead of a thousand. Instead of ruling deep grooves on glass, a grating may be built up of a number of equally thick plates pressed together and sheared through an angle of 45° or other angle, the projecting edges of which make ridges and grooves of constant dimensions. Since the resolving power is independent of the number of plates, but depends only upon the total thickness and the order of the spectrum picked out, a small number of elements, say twenty 5 mm. thick, suffices to give a dispersion of 100,000. The Zeeman effect is readily observed with such an apparatus. The only advantage of narrower grooves lies in the better separation of successive spectra. E. E. F.

755. *The Modifications of the Spectra of Substances radiating in a Magnetic Field.* **T. Preston.** (Roy. Soc. Proc. 63. pp. 26–31, 1898.)—The author gives an account of observations made during an investigation of the influence of a strong magnetic field on the spectral lines of various substances. The spectra were photographed under the influence of the magnetic field, and the photographs show that the spectral lines are very differently affected, even for the lines of the same substance. Iron, being a mangetic substance, was especially examined, but no special peculiarity marked its spectrum, and the same may be said of gases. The effect, as measured by the distance between the side lines of the triplet viewed across the lines of force, or of the components of the doublet viewed along the lines of force, appears to be no simple function of the wave-length, being often widely different for lines of approximately the same wave-length, nor does this effect appear to be in any way parallel to the pressure effect observed by Messrs. Humphreys and Mohler. AUTHOR.

756. *Connection between the Faraday and Zeeman Effects.* **Geo. F. FitzGerald.** (Roy. Soc. Proc. 63. pp. 31–35, 1898.)—The author connects the rotation of the plane of polarisation of plane polarised light passing through matter placed in a magnetic field with the changes of frequency produced when the source of light is placed in a strong magnetic field. That is, the change of velocity produced in the former case is connected with the change of frequency produced in the latter. Starting with the idea that the dispersion in the spectrum is controlled by a strong absorption-band in the ultra-violet, it follows that if this absorption-band be changed by any cause, the dispersion will also be altered, and with it the velocity of light in the spectrum, so that the change of frequency and the change of velocity, that is the Zeeman and the Faraday effects, become connected by any form of general

dispersion theory connecting the frequency and velocity. The equation deduced is of the form

$$\mu^2 = \mu_0^2 + \frac{a}{\lambda^2} \pm \frac{a}{\lambda} \cdot \frac{\rho H}{2\pi V_0},$$

and this is shown to lead to appproximately the same value of the effect as has been observed experimentally. T. P.

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757. *Radiation in a Magnetic Field.* **H. A. Lorentz.** (Annal. Phys. Chem. 63. 1. pp. 278–284, 1897.)—Assume that a luminous molecule may be regarded as a dynamical system depending upon n normal coordinates θ_r and oscillating about a position of stable equilibrium, so that $2T = \Sigma a_r \dot{\theta}_r^2$, $2U = \Sigma b_r \theta_r^2$, and the frequency k_r of a typical vibration is $\surd(b_r/a_r)$. Neglecting the magnetic forces called into play by the moving ions themselves, the equations of motion in a magnetic field will be

$$a_r \ddot{\theta}_r + b_r \theta_r + \sum_s c_{rs} \dot{\theta}_s = 0,$$

where $c_{rs} + c_{sr} = 0$. Put $\theta_r = \mu_r e^{ilt}$ and eliminate the quantities μ_r: the result is an equation in l, the frequency of a principal vibration in the disturbed motion. If $k_1, k_2, \ldots k_n$ are all different, the value of l_1 (corresponding to k_1) is approximately

$$l_1 - \tfrac{1}{2}\delta,$$

where

$$\delta = \left[\frac{c_{12}^2}{a_1 a_2 (k_2^2 - k_1^2)} + \frac{c_{13}^2}{a_1 a_3 (k_3^2 - k_1^2)} + \ldots + \frac{c_{1n}^2}{a_1 a_n (k_n^2 - k_1^2)}\right] k_1.$$

Suppose now that in a source of light there are a large number of equal and similar but differently oriented luminous particles. Then by taking normal coordinates for each, the above analysis applies to all, but the coefficients c are different, and δ will acquire values between two fixed limits; consequently the spectral line will undergo a widening and also, in general, a lateral displacement. The effect depends upon the square of **H**, and is probably too small to be observed in such fields as are practically obtainable.

Suppose now that $k_2 = k_1$, all the other k's being different; there will be two corresponding values of l, which are approximately

$$k_1 \mp \frac{c_{12}}{2\surd a_1 a_2},$$

and the change is comparable with the first power of **H**.

To explain the Zeeman effect on these principles, we must suppose (i) that three principal vibrations have the same period, and (ii) that the influence of the magnetic force does not depend upon the orientation. On these assumptions, taking $k_1 = k_2 = k_3$,

we have for the corresponding disturbed motion three frequencies, k_1 and

$$k_1 \pm \frac{1}{2}\sqrt{\left(\frac{c_{12}^2}{a_1a_2}+\frac{c_{23}^2}{a_2a_3}+\frac{c_{31}^2}{a_3a_2}\right)},$$

where the quantity in brackets is of the form $C(H_x^2+H_y^2+H_z^2)$.

G. B. M.

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758. *Partial Polarisation of Light in a Magnetic Field.* **H. A. Lorentz.** (Écl. Électr. 14. pp. 311–313, 1898.) [*Cf.* Kon. Ak. van Wetenscheppen (Academy of Sciences of Amsterdam), vi. pp. 193–209, 1897.]—1. This paper is an abstract and discussion by **A. Cotton** of Lorentz's views based on the experiments of Egoroff and Georgiewsky, in which they discovered the partial polarisation of light emitted normally to the lines of force by a flame placed in a magnetic field. Lorentz has repeated the experiments, and has verified the fact that the partial polarisation is manifested in a relatively feeble magnetic field (of the order 1·0 C.G.S.). With an intense field he finds the proportion of the light polarised to be about 12 % of the total light emitted. This agrees with the result of Egoroff and Georgiewsky. Moreover, he finds that it is the vibrations normal to the field which are the important ones.

2. Lorentz seeks then to connect together these experiments and those of Zeeman, and his own theory on the motion of ions in a magnetic field. Designating by I_1, I_2, I_3, the intensities perpendicular to the lines of force, of the three components of the triplet observed by Zeeman, of which the periods are T_1, T_2, T_3, we should have $I_1+I_3>I_2$, so that one is led to ask if the circular motions of the ions which produce the lateral rays of periods T_1, T_3, and the rays of same period of the doublet observed in the direction of the lines of force, have more importance than the vibrations parallel to the lines of force which have kept the original period T_2. *A priori* it seems as if in a magnetic field the circular vibrations should be privileged. One is even led to ask if the two circular vibrations which have the one the sense of the amperian currents, the other the contrary sense, have the same intensity. On examining the light emitted in the direction of the lines of force in which alone the two sorts of circular vibrations propagate themselves, Lorentz does not find any sensible difference of intensity between them. He employs a quarter-wave plate which would transform the polarisation rectilinearly, so that it may be detected by an ordinary polariscope. Lorentz besides remarks that his theory predicts nothing of the sort. Calling τ the change of period

$$T_1=T_2+\tau, \quad T_3=T_2-\tau,$$

the intensities I_1, I_3 should not differ from $I_2/2$ except by a very small fraction, of the order $\frac{\tau}{T}$, which would be quite imperceptible.

3. Thus the phenomenon of Egoroff and Georgiewsky would seem to contradict the theory of Lorentz. But Lorentz makes the following very important remark:—The intensity really observed depends not only on the vibratory state *at a point* of the source, but also on the *absorption* that the vibrations experience whilst traversing the successive layers of the flame. In particular, the vibrations proceeding from the hinder part of the flame are enfeebled by their passage towards the front part. When the magnetic field is excited this absorption should diminish, according to Lorentz, for the vibrations perpendicular to the field which alone experience the change of period. Admitting that each component of the triplet is given by a determinate group of ions, a first group of ions A_2 would be composed of the ions vibrating parallel to the lines of force with the period T_2; two other groups would vibrate in a plane perpendicular to the lines of force, with the periods T_1, T_3 respectively.

The absorption of the vertical vibrations (those perpendicular to the field) proceeding from the posterior part of the flame, and which have the period T_1, is produced only by *one* of the groups of ions, the group A_1, formed of ions which have precisely the same period. If the field is suppressed, this absorption is produced by two groups of ions A_1, A_3, since the periods T_1, T_3 then coincide with the original period T_2. The same remarks apply to the vertical vibrations of period T_3. On the other hand, the vibrations parallel to the lines of force, of period T_2, would be absorbed in the same way within the field, and outside it (by the ions A_2); for *Lorentz admits that even outside the field the absorption of a polarised ray is produced solely by those of the ions which vibrate in the plane of vibration of the incident ray.* Natural light observed outside the field would then be transformed into light partially polarised in a horizontal plane, conformably to experiment.

4. Lorentz makes the following experiment to show that the absorption in the flame placed in the field can produce a partial polarisation. A flame F_1 is placed in the field (13,000) of the electromagnet. The flame is feebly charged with sodium. A second sodium flame F_2, limited by a diaphragm, is placed behind the first on the straight line perpendicular to the field along which the observer looks. On observing, with Savart's polariscope, the diaphragm placed against F_2, sharply defined fringes appear on its surface, indicating that the light of this flame F_2 is polarised by its passage across F_1. The polarisation is of the same sense, but more marked than that of the light sent out by F_1; it is perceived even when the light from F_1 is too feeble to be studied by the polariscope.

5. In certain circumstances, for instance when repeating the experiment with a flame F_2 which is very intense, a polarisation contrary in sense to that from F_1 has been observed; then it is the horizontal vibrations which produce the result. The author interprets this experiment by remarking that the rays in the light of F_2 are then very broad, broader than the entire triplet given by

the flame in the field. The vertical vibrations of period T_1, T_3 contained in the light of F_2 are then absorbed by the ions A_1, A_3.

6. In the remainder of the paper Lorentz develops certain calculations on the theory of motion of the ions in the magnetic field. He neglects completely in his calculations the inertia of the ether. [*Cf.* Poincaré, L'Écl. Électr. 11. p. 481.] He examines the influence of the variable period during which the field becomes established. The formula which is arrived at, and which gives the absolute change of period, is:

$$\tau = \frac{eH}{4\pi m} T^2,$$

where T is the original period, H the field, $\frac{e}{m}$ the ratio of the charge of the ion (in E.M. units) to its mass. According to this formula the *absolute* change of period would be, *for a given ion*, proportional to the square of the period and *independent of the temperature.* The last point especially appears accessible to experiment. J. J. S.

759. *Polarisation of Light in a Magnetic Field.* **A. Cotton.** (Écl. Électr. 14. pp. 299–300, 1898.)—The author discusses the experiments of Egoroff and Georgiewsky (see Phys. Soc. Abstracts, Nos. 382, 461, & 577, 1897), and the explanation of these given by Lorentz (Abstr. No. 758). These experiments may be easily repeated, but it is essential that a flame but slightly charged with sodium, and thus moderately bright, be used. The author mentions several forms of polariscope which may be used to view the fringes.

Lorentz implicitly makes a new enunciation of the principle of Kirchhoff; instead of the usual statement that a vapour absorbs the radiations which have the same period as the radiations which it emits, it is necessary to say that a vapour absorbs the radiations which have the same period and the *same direction* as its own vibrations. Perhaps this is the correct enunciation of the law of Kirchhoff, *at least when the absorbing layer is placed in a magnetic field.* In this case the vibrations of a certain period which are produced have necessarily a determined direction or sense, and are in some sort *forced.* J. J. S.

760. *Polarisation of Light by Rubber.* **A. H. Bruère.** (Phys. Rev. 6. pp. 140–152, 1898.)—At an angle of 58° the polarisation of yellow light by hard rubber or ebonite is as complete as polarisation by glass, where the maximum occurs at 56°. This result does not agree with those of Jamin, who found that only a few substances completely polarise light by reflection, and that for these $\mu = 1{\cdot}46$. The refractive index of hard rubber for sodium light, as determined from the angle of polarisation, is 1·6. The completeness of the polarisation suggests the use of hard rubber as a substitute for black glass in polarising apparatus. E. E. F.

761. *Radiation of a "Black" Body.* **O. Lummer** and **E. Pringsheim.** (Annal. Phys. Chem. 63. 1. pp. 395–410, 1897.)—The authors attempt to realise Kirchhoff's conception of an equivalent to an absolutely black body in the shape of a uniformly heated hollow space with a small opening, and test Stefan's law, which maintains that the radiation of such a body is proportional to the 4th power of its absolute temperature. Different temperatures, ranging from 100° to 1300° C., are produced by boiling water, by a mixture of potassium and sodium nitrates, and by an oxy-coal gas flame. Radiations are measured by the bolometer. The Stefan-Boltzmann law is confirmed to within 3 to 8 °/₀. All the differences between the theoretical and experimental values would be eliminated by substituting 3·96 for 4 as the index of the absolute temperature. E. E. F.

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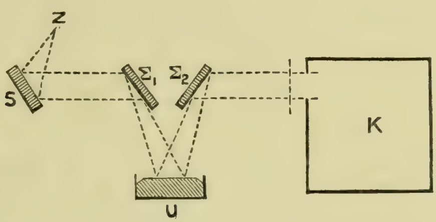
762. *Heat-Rays of Great Wave-Length.* **H. Rubens** and **E. Aschkinass.** (Annal. Phys. Chem. 64. 3. pp. 602–605, 1898.)—It having been found that water-vapour absorbs the infra-red rays transmitted by fluor-spar, it is of interest to enquire whether liquid water does the same. On account of absorption by almost all known substances, the rays must be transmitted through water not contained in a vessel with parallel sides. The arrangement adopted is shown in the diagram. Light from a zirconium burner



Z is reflected by a concave mirror S and a plane mirror Σ, on to a mercury-surface U, and then by further reflections into a box K containing the usual fluorspar reflecting surfaces and the thermocouple. After a first reading, a thin sheet of water is laid over the mercury. The absorption is very considerable. The refractive index is of the same order as for the visible spectrum, and the value 9 is probably not reached until $\lambda = 24\ \mu$. The comparative intensities of reflected rays obtained with other liquids are: ethyl alcohol 5, carbon bisulphide 23, benzol 49, phenol 5, xylol 9, with a layer 5 mm. thick. It appears that benzol is very transparent for these rays ($\lambda = 0{\cdot}5$ to $1{\cdot}8\ \mu$), even more so than chloride of silver. The substitution of a hydroxyl group for a hydrogen atom (phenol) considerably increases the absorption, just as it does in other substances. E. E. F.

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763. *Fluorescence and Photoelectricity.* **G. C. Schmidt.** (Annal. Phys. Chem. 64. 4. pp. 708–724, 1898.)—The Wiedemann-Schmidt theory of fluorescence supposes that it is due to the recombination of ions after exposure to light. Since the negative ion is more easily "discharged" in photoelectric bodies than the positive ion, it might be expected that the most highly fluorescent bodies would be the least photoelectric. But no such connection between the two bodies can be established. A brilliantly fluorescent "solid solution" like $SrS + xCu_2S$ is also strongly photoelectric. The haloid salts of silver and sodium agree in not showing any fluorescence. But whereas the silver salts are highly photoelectric, the sodium salts are not at all. It is found, however, that thermoluminescence and photoelectric sensitiveness are invariably associated if either of these qualities is strongly marked.

E. E. F.

764. *Visibility of Röntgen Rays.* **E. Dorn.** (Annal. Phys. Chem. 64. 3. pp. 620–622, 1898.)—That the light effect of Röntgen rays is not due to an act of "accommodation," as has been alleged, has been proved by the author with the aid of a medical friend, who intentionally paralysed the accommodation capacity of one of his eyes with homatropine, and found the visual effect as strong as before. The fact that a straight rod sometimes casts a bent shadow into the eye is explained by considering that Röntgen rays are not refracted by the humours of the eye. The rods therefore cast straight lines on the retina, which are ordinarily only produced by bodies bent in a certain manner. The straight lines are therefore interpreted as being due to bent rods. E. E. F.

765. *Transformation of Röntgen Rays.* **G. Sagnac.** (Écl. Électr. 14. pp. 466–474, 1878.)—This paper deals with the production of "secondary rays, or S-rays" (see Abstract No. 245).

A. D.

766. *Uranite Rays.* **E. Villari.** (L'Elettricista, Rome, 7. 5. pp. 101–103, 1898.)—The paper describes experiments on the property possessed by uranite of discharging electrified bodies. The electrified body was a gold-leaf electroscope, which lost from leakage 1° in 90″. On placing a piece of uranite 1 cm. from the electroscope-knob the loss was 1° in 7″. Sending a current of air transversely between the knob and the uranite slightly reduced the loss to 1° in 8″. To ascertain to what extent the discharging power persists, the uranite was placed in a tube 20 cm. from the electroscope. This lost 1° in 24″ when a current of air or of illuminating gas was directed through the tube against the electroscope-knob. Increasing the distance to 190 cm., the loss was 1° in 54″. The loss without the uranite was 1° in 148″. Further the author found that when a metal point was placed in the air-

current, the phenomena were the same as in the case of gas subjected to Röntgen rays. Without the uranite and with the point to earth, the loss was 1° in 134″; with the uranite, 1° in 25″. With electroscope and point charged to opposite potentials, 1° in 43″; to similar potentials, 1° in 156″. If, however, the charged point were close to the end of the tube and nearly equal in size to its diameter, the discharging power was entirely lost. When the uranite was closed in a paper envelope no action was observable, though an image was obtained on a sensitive plate through black paper after an exposure of 24 hours. G. H. Ba.

HEAT.

767. *Kelvin's Absolute Method of Graduating Thermometers.* **J. Rose-Innes.** (Phil. Mag. 45. pp. 227–234, 1898.)—Kelvin has examined the cooling effects exhibited by various gases in passing through a porous plug; and he found that the effects for any one gas kept at the same initial temperature were proportional to the difference of pressure on the two sides of the plug (Reprinted Papers, vol. i. pp. 333–455). He also found that the cooling effect for air per unit difference of pressure varies as the inverse square of the absolute temperature. It is suggested in the present paper that better results may be obtained by putting

$$\text{cooling effect per unit difference of pressure} = \frac{\alpha}{T} - \beta,$$

where α and β are constants characteristic of the gas, and T is the absolute temperature. The proposed new formula has the further advantage that it applies readily to the cases of carbonic acid and hydrogen. Among the consequences deduced from the formula it is shown that there is no thermodynamic correction needed, for a constant-volume gas-thermometer, involving the first power of the cooling effect. AUTHOR.

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768. *Acoustic Thermometer.* **G. Quincke.** (Annal. Phys. Chem. 63. 1. pp. 66–71, 1897.)—This thermometer, which is intended for the measurement of both high and low temperatures, depends for its action on the variation of the velocity of sound in air with change of temperature. The thermometer consists of a wide tube of metal or more refractory substance, closed at one end, which end is placed in the furnace. A vibrating tuning-fork of known frequency is placed at the open end, and the wavelength in the heated air in the tube is measured by finding the nodes and ventral segments produced by interference in the tube. These are located by means of a long thin tube inserted in the other; a rubber tube, connected to the outer end, conveying the sound transmitted through this thin tube to the ear. By moving the thin tube backwards and forwards in the other, the positions of maximum and minimum sound are noted and measured; and, the frequency being known, the velocity is at once determined, and hence also the temperature. J. B. H.

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769. *Determination of Vapour-Pressures.* **E. B. H. Wade.** (Roy. Soc. Proc. 62. pp. 376–385, 1898.)—The boiling-points of pure water and of an aqueous solution boiling simultaneously under identical conditions are measured by means of platinum-resistance thermometers. Errors due to variations in the barometric pressure, rate of ebullition, height of flame employed, depth of experimental liquid, and other circumstances are thus eliminated.

The apparatus employed is described in detail. The essential parts are a closed drum consisting of a cylinder of glass the ends of which are closed by plates of tinned brass, and two smaller cylindrical tubes open at one end and terminating below in narrow tubes of brass. These two tubes are fixed side by side within the drum, their narrow tubes communicating with the exterior. These two tubes contain water and solution respectively. The greater part of a current of steam passes directly into the drum jacketing the two tubes, a smaller part of it bubbles through the two liquids, the temperatures of which are read by means of platinum thermometers. Arrangements are provided for keeping the depth of liquid in the two tubes constant or equal, and for maintaining any desired pressure in the drum. The electrical measurements are made in the way described by Griffiths. When the readings of the boiling-points have been completed, a sample of the solution is withdrawn for analysis. T. E.

770. *Vapour-Tension of Mercury.* **L. Pfaundler.** (Annal. Phys. Chem. 63. 1. pp. 36–43, 1897.)—In the experiments the author saturates dry air with mercury-vapour by passing it through tubes containing glass-wool on which finely divided mercury has been deposited. The mercury is then absorbed by passing the air through a tube containing silver foil, the tube being weighed before and after an experiment. The volume of air is measured by a gas-meter, and its temperature of saturation is kept definite by enclosing the mercury-tubes in an air-bath surrounded with the vapour of a boiling liquid. By continuing the experiments for many hours quantities of mercury are absorbed, which can be accurately weighed. The results agree with those obtained by Hertz, within the limits of experimental error. J. B. H.

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771. *Vapour-Pressures of Mutually Soluble Liquids.* **W. Ostwald.** (Annal. Phys. Chem. 63. 1. pp. 336–341, 1897.)—This paper contains a theoretical consideration of the vapour-pressures of a mixture of two liquids in the cases when the two liquids dissolve each other, either completely or only partially. By the aid of curves, having for ordinates the vapour-pressures of each liquid and for abscissæ the molecular proportions of the liquid present in the mixture, the author accounts for all the observed phenomena. That mixture of the two liquids which distils unchanged is accounted for by a maximum ordinate in the curve of total vapour-pressure, the ordinates of which are the sum of the ordinates of the other two. The cause of the incomplete mixing of some liquids is accounted for by assuming that here each of the two curves of vapour-pressures possesses a maximum and a minimum ordinate, the maximum of one curve coinciding with the minimum of the other in such a manner that the curve of total pressures assumes where the mixing is incomplete its horizontal straight-line form. J. B. H.

772. *Vapour-Tension of Concentrated Hydrochloric Acid.* **F. B. Allan.** (Journ. Phys. Chem. 2. pp. 120–124, 1898.)—Air was saturated with HCl at 18°·4 C. by bubbling in very fine streams through aqueous solutions of definite strengths, and was then passed through water in Geissler bulbs. The amount of HCl in the latter, and the vapour-tension were then determined and plotted. The curve was found to be regular. If, however, the vapour-tensions be assumed to be proportional to the amount of undissociated HCl, the values for dissociation (as compared also with Kohlrausch's conductivity and Jones's cryoscopic figures, which are also given) will be found to be impossible for such concentrated solutions. Therefore electrolytic dissociation is not an adequate explanation of the fact that HCl solutions do not obey Henry's law. S. G. R.

773. *Measurement of Low Temperatures.* **G. W. Meyer.** (Elektrochem. Zeitschr. 5. pp. 6–10, 1898.)—The paper gives an account of the various methods available for the measurement of very low temperatures—the hydrogen thermometer, thermo-couples, and the platinum resistance thermometer. The author then suggests a method depending on the change of permeability of iron with temperature, and gives a diagram showing the arrangement of connections for use with a ballistic galvanometer. He does not state that he has tried the method, and no experimental data are given. A. H.

774. *Linde's Method of Liquefying Air.* **J. A. Ewing.** (Soc. Arts. Journ. 46. pp. 375–381, 1898.)—The principal part of this regenerative apparatus (fully illustrated in the paper) is a vertical copper worm called an "interchanger," consisting of two concentric tubes, the inner one passing through a nearly closed throttle-valve into a vacuum-jacketed chamber, with which the outer annular space communicates freely. The pressure in the chamber is maintained by a pump at 16 to 50 atmospheres. A second pump compresses the air to 200 atmospheres, and forces it first through a bath of ice and salt to cool it and deposit moisture, then down the inner tube to the aperture of the valve. Kelvin and Joule found that when compressed air expands by passing through a constricted orifice, the temperature falls by about $\frac{1}{4}$° C. for each atmosphere difference of pressure between the two sides of the orifice. The gas thus expanded and refrigerated escapes upwards through the annular space, and thus effects a cumulative cooling on the high-pressure air which is approaching the valve. A temperature of −200° or under is attained without difficulty, when a portion of the air is liquefied in the chamber, the remainder returning to the pumps. About 0·9 litre of liquid is formed per hour with a continuous expenditure of 3 horse-power. Another form of the apparatus effects the concentration of oxygen to 65 per cent. by the slow evaporation of the liquid air, when the

nitrogen distils first. A new machine for use in the Deacon chlorine process is expected to yield about 1 lb. of liquid air per H.P. hour. An explosive of great power, capable of use with a detonator, is made by pouring the liquid containing 40 to 50 per cent. oxygen on granulated wood charcoal mixed with cotton-wool. In thick cardboard cases it retains its explosive power for 5 or 10 minutes. Trials are in progress at Munich and in a Penzberg coal-mine. S. G. R.

SOUND.

775. *Vibrations of a Rectangular Plate.* **C. Zeissig.** (Annal. Phys. Chem. 64. 2. pp. 360–397, 1898.)—For transverse vibrations of a rectangular elastic plate with free edges no integration of the differential equations has up to the present been successfully carried out. But if two opposite edges are fixed, the vibrations are both practically feasible and amenable to theoretical treatment. The author gives a complete mathematical solution, based upon the fundamental equations established by Voigt, and then proceeds to compare his calculations with actual results. To do this he photographs the glass plates with the theoretical drawings and the actual sand curves. These show a close agreement wherever the theoretical assumptions are fulfilled. The figures due to simple vibrations have the appearance of a grating composed of straight intersecting nodal lines parallel to the edges. The notes have pitches proportional to the thickness and inversely proportional to the square of the side-length of the plates. E. E. F.

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776. *High Pitches.* **A. Appunn.** (Annal. Phys. Chem. 64. 2. pp. 409–416, 1898.)—Defends the correctness of the pitches indicated on his pitch-pipes against the criticism of Stumpf and Meyer. The indications of a recording tuning-fork loaded with a stylus are not reliable, inasmuch as even a scratch with a file will raise the pitch of the smaller forks very considerably. The pitch of the pipe-notes depends of course upon the pressure of the wind, but when they are blown with a certain specified pressure their pitches are absolutely constant for a given temperature. Stumpf and Meyer's assertion that the pipe marked "50,000" gives only 10,000 vibrations per second is probably due to the disturbing effect of combination tones, in which the humming of the wind on entering plays a part. E. E. F.

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777. *Attenuation of Sound.* **A. W. Duff.** (Phys. Rev. 6. pp. 129–139, 1898.)—Theory indicates that the intensity of sound varies as

$$\frac{\epsilon^{-2mr}}{r^2},$$

where r is the distance, and m is a factor involving viscosity, conduction, and radiation. Two of these effects increase very rapidly with increase of pitch, while the third, due to radiation, is independent of the pitch. Experiments made with a number of whistles blown separately or together under the same pressure show that eight whistles are, on the average, audible about one-fourth further than a pair of whistles; whereas, if the spherical nature of the wave were the only cause of attenuation, the distances would be as two to one. Since refraction and reflection

contribute little to the diminution of intensity observed, it appears that radiation is about seven times as effective as viscosity, and about eighteen times as effective as conduction in reducing the intensity of a note whose vibration frequency is 7000. But for a note of medium pitch, say 350, radiation must far transcend viscosity and conduction in effect, being in fact nearly 3000 times as effective as viscosity, and over 7000 times as effective as conduction. The whole rate of diminution of total energy would, so far as these three causes are concerned, be practically that of radiation alone, or about $\frac{2}{3}$ per cent. per metre.

From the experiments the constant of radiation of air may also be calculated. Its value is about 8·3. It follows that a mass of air at any given excess of temperature above its surroundings will, if its volume remains constant, fall by radiation to one-half of that excess in about one-twelfth of a second. E. E. F.

ELECTRICITY.

778. *Electrical and Hydrodynamical Analogies.* **C. A. Bjerknes.** (Annal. Phys. Chem. 63. 1. pp. 91–96, 1897.)—The author deals in a provisional manner with the probable developments of hydrodynamical analogies as applied to electricity in motion. He points out that the pulsating sphere will have to be retained as the analogue of the uniformly charged body, and that viscosity will have to be called into play in extending the analogy to dynamic electricity. E. E. F.

779. *Measurement of Magnetic Dip and Intensity.* **G. Meyer.** (Annal. Phys. Chem. 64. 4. pp. 742–751, 1898.)—The author describes a simplified method of measuring these quantities. The dip is measured by the earth inductor. A position is sought in the plane of the magnetic meridian at which the revolution of the coil produces no current in the galvanometer. The inductor is kept moving by a belt-and-pulley arrangement, and the presence of alternating currents is tested for by means of a telephone or a capillary electrometer. Every half-revolution of the inductor produces a very audible tick in the telephone, unless the axis of revolution is strictly parallel to the earth's lines of force. The intensity is measured by compensating the earth's field with a known current sent through two large coils surrounding the earth inductor. The latter is exceedingly sensitive to the smallest field-intensity. E. E. F.

780. *Capacity of Condensers.* **F. Lori.** (Roma, R. Accad. Lincei, Atti, 7. pp. 150–157, 1898.)—The object of this research is to find out whether anything analogous to magnetic hysteresis occurs when a condenser is gradually charged up and then gradually discharged. One armature of a Siemens mica condenser (capacity 1 microf.) is put to earth, and the other connected with a quadrant electrometer. The two pairs of quadrants are connected by wires to the poles of a battery, the centre of which is to earth. From a point on the wire joining condenser and electrometer a wire proceeds to a galvanometer; finally, by means of another wire proceeding from the galvanometer, contact can be made with any cell of another battery, the centre of which is to earth. The galvanometer was one of the Siemens type, with four coils and two field-magnets, and was used ballistically. To obtain consistent results, it is necessary first to charge and discharge the condenser a good many times between limits exceeding those of the cycle to be investigated; and between the successive charges (*i. e.* the instantaneous contacts with the different elements of the second battery) a short and constant interval should be allowed to elapse. Under these conditions it is found that, within the limits

of experimental error, the charge of the condenser is proportional to the difference of potential of the armature; so that there is no evidence of "electrical hysteresis." The charge was estimated by adding the successive readings of the galvanometer; the differences of potential could not be observed directly, because the interval between the successive contacts was too short; each potential-difference was calculated from three successive elongations a minute after contact. Accordingly, as the author remarks, what is actually observed is the constancy of V'/q, where q is the charge at time t and V' the potential-difference at time $t+t_0$. However, by another method, to be subsequently communicated, the author has overcome this difficulty, and obtained similar results for mica, paraffin, glass, and ebonite. G. B. M.

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781. *Mutual Influence of Electric Sparks.* **J. I. Károly.** (Annal. Phys. Chem. 62. 4. pp. 612–615, 1897.)—The primary spark-gap is between two electrodes, each of which is connected to a large insulated zinc plate. Parallel to these plates and similarly situated are other two similar plates, attached to which are the electrodes forming the secondary spark-gap, the spark in the secondary gap being due to resonance. The influences on the secondary spark of different forms of electrodes, of the ultra-violet light from the primary spark, of connecting the secondary electrodes to earth both directly and through water-resistances, and of the proximity of the hand to the secondary circuit, are all given in the paper. J. B. H.

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782. *Unipolar Discharges in Rarefied Gas.* **A. Battelli.** (N. Cimento, 7. pp. 81–104, 1898.)—When both electrodes of a vacuum-tube are connected to the same pole of an influence-machine or induction-coil the tube becomes luminous, the luminosity filling the tube with the exception of a single perfectly dark space. This space occupies the centre of the tube if the electrodes are connected to the pole by paths of equal resistance, and increase of resistance in either path causes it to shift towards the side of greater resistance. On bringing an earth-connected body near the tube, the dark space moves away from the body. All these phenomena occur in the same manner whether the pole be positive, negative, or both alternately. The author describes in detail the changes observed in the illumination of the tube as the potential of the electrodes is raised, and as the pressure of the gas is gradually diminished; minor differences exist according as the electrodes are positive or negative. By means of a series of small spherical conductors inserted between the two electrodes, it is found that the potential falls from a maximum at each electrode to zero or nearly so in the dark space. When the gas is very highly rarefied the dark space disappears, the potential becomes uniform throughout the tube, and the characteristic green

fluorescence is seen whether the electrodes be positive or negative; in each case the fluorescence is brightest on the wall of the tube opposite the electrode. The author describes experiments which indicate the existence of anode and kathode rays: both kinds produce fluorescence, but the kathode rays when they impinge on the walls of the tube are reflected or scattered to a greater extent than the anode rays; both kinds are acted upon by a magnet and by an electrostatic field; and both exert a photographic action, that of the anode rays being the more intense. Both rays travel at a speed comparable with that of light. The direction of the magnetic deflection depends on the pressure of the residual gas, and is the same for anode as for kathode rays. The photographic effect of the anode rays is diminished by the presence of a kathode, whereas that of the kathode is increased by the presence of an anode; so that, in the case of ordinary discharges, only the latter action is detected. J. L. H.

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783. *Deflection of Kathode Rays.* **W. Kaufmann** and **E. Aschkinass.** (Annal. Phys. Chem. 62. 4. pp. 588–595, 1897.)—One of the authors has in a previous paper (Wied. Annal. 61. p. 544, 1897) communicated the results of his experiments on the deflection of kathode rays in a magnetic field; and on the assumption that the rays are electrified particles, he calculated the ratio of the mass to the charge. Assuming the value of this ratio, the authors have now calculated the deflection which the rays should undergo in an electrostatic field, and they have experimentally proved that the deflection of the beam on passing near a second kathode in a specially constructed vacuum-tube is in agreement with the calculated value. J. B. H.

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784. *Deflection of Kathode Rays.* **W. Kaufmann.** (Annal. Phys. Chem. 62. 4. pp. 596–598, 1897.)—This paper is a supplement to a former one by the same author (Wied. Ann. 61. pp. 544–552, 1897). In the former one, in calculating the ratio e/m no allowance was made for the variation in the strength of magnetic field from point to point. This variation has now been experimentally determined, and the value of e/m obtained is $1{\cdot}77 \times 10^7$ c.g.s./gramme. J. B. H.

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785. *Kathode Rays.* **E. Wiedemann** and **G. C. Schmidt.** (Annal. Phys. Chem. 62. 4. pp. 603–611, 1897.)—Kathode rays are usually present in two different forms—first, the ordinary slightly conical beam forming a solid cone of rays, and secondly the beam diverging from about the same point as the other but in the form of a conical mantle forming rings or ovals where it meets the tube. The authors have here investigated the cause of the latter and the influences which regulate its form. Its cause is

attributed to rapid oscillatory discharges ; and in the experiments the authors used tubes without electrodes, and excited discharges in them by means of a Lecher system of wires. The electrodes consisted of balls or rings pressed against the outside of the tube. The angle of the cone of rays diminishes with the curvature of the glass, increases rapidly with the curvature of the electrode, and increases rapidly with diminution of pressure of gas. The authors suggest the following explanation of these and all similar phenomena:—

(1) Rapid oscillatory discharges in rarefied gases take place near the surface as in metal conductors, but in gases are prevented from reaching the surface by the walls of the tube acting as a kathode, the discharge being thus separated from the walls by a dark kathode space.

(2) The kathode rays leave the surface between the solid and the gas in the direction in which the oscillatory discharge is penetrating that surface. In air at atmospheric pressure the direction in which the oscillations leave a conductor is perpendicular to the surface of the conductor, so that if a metallic sphere is laid against the tube the kathode rays start perpendicular to the surface of the sphere. The angle of the cone only reaches a certain magnitude, owing to the distance between the sphere and the gas in the tube being too great beyond that angle. This critical distance is attained at a smaller angle the greater the curvature of the sphere. If the metal is surrounded by rarefied gas, as is the case with internal electrodes, then the dark space influences the direction in which the oscillations leave the kathode and cause it to be no longer perpendicular to the surface. J. B. H.

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786. *Electrostatic Properties of Kathode Rays.* **P. Lenard.** (Annal. Phys. Chem. 64. 2. pp. 279–289, 1898.)—Experiments carried out on the lines of those made by J. J. Thomson and W. Wien lead to the result that kathode rays behave in every respect as if they consisted of moving particles possessed of inertia and conveying negative electric charges. Kathode rays emerging through a "window" and entering an observation-space, produce an electric charge on any surface on which they impinge, even if the window is put to earth and the observation-space is a perfect insulator. When a field is created between two condenser-plates in the observation-space, the rays are bent towards the positive plate. Those rays which suffer the strongest magnetic deflection also undergo the strongest electric deflection. The velocities of the various rays differ a little. They are probably about one-third of the velocity of light. E. E. F.

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787. *Nodes in Kathode Rays.* **E. Wiedemann** and **A. Wehnelt.** (Annal. Phys. Chem. 64. 3. pp. 606–610, 1898.)—When a magnet is placed opposite the kathode of a vacuum-tube,

or the latter is enclosed in a solenoid, the lines of force are parallel with the rays, and the latter are twisted into a succession of loops or segments which bear some resemblance to those of a vibrating string. The phenomenon may be fully explained by the projected-particle theory of kathode rays. The feebler the field, and the higher the velocity of projection (*i. e.* the potential and the exhaustion), the longer are the corresponding segments. The glow-light is not similarly affected. E. E. F.

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788. *Damping of Electric Resonators.* **S. Lagergren.** (Annal. Phys. Chem. 64. 2. pp. 290–314, 1898.)—The damping of a Hertzian resonator may be determined by the method proposed by Bjerknes. But one must take care that the distance between the oscillator and the resonator is so large that no difference is produced in the damping effect by increasing it. The total decrement is due to the development of Joulean heat and to radiation. No energy is given off to the molecules of the surrounding air, unless the E.M.F. is very strong. The damping due to heat may be calculated by means of the old electrodynamics. As regards damping by radiation, the Hertzian resonators may be divided into two classes. The open (rectilinear) resonators show the strongest damping, and seem to obey the simplest laws. The damping of both open and closed resonators decreases as the capacity increases. E. E. F.

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789. *Self-Induction of Resonators.* **R. Blondlot.** (Annal. Phys. Chem. 64. 4. pp. 811–812, 1898.)—Points out that in his calculation of the self-induction of resonators in 1891 (Journal de Physique, p. 552) he had omitted the factor 2 in the term containing the mutual induction of the parallel wires. On introducing this term, the systematic errors disappear, and the results agree with those obtained by Mascart. E. E. F.

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790. *Electric Vibrations of Long Period.* **J. Bergmann.** (Annal. Phys. Chem. 64. 4. pp. 685–707, 1898.)—The author uses four Rayleigh mercury contacts, two of which are mounted on each arm of a lever which is kept oscillating by a steel spring worked by means of another intermittent current on the Ruhmkorff principle. The four contacts can be inserted either in the charging or the discharging circuit of a condenser. The latter may be charged and discharged any given number of times per second, and the part of the oscillations picked out for measurement is determined by the position of the dippers with respect to the mercury cups. The author succeeded in maintaining a remarkably steady deflection of the galvanometer through a large number of oscillations. E. E. F.

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791. *Damping of Electric Oscillations.* **M. Planck.** (Annal. Phys. Chem. 63. 1. pp. 419–422, 1897.)—The damping of electric oscillations in stationary conductors is usually attributed to the resistance of the circuit, in some cases the hysteresis etc. playing an important part. This damping is entirely dependent on the materials composing the circuit, and by a suitable choice of these can be more or less avoided; but there is another damping which is inseparably connected with the oscillations themselves and is not influenced by the materials, namely, that due to the propagation of the energy of oscillation through the surrounding space. This the author calls "conservative" damping, because no energy of oscillation as such is lost. With comparatively slow oscillations the conservative damping is very small, and therefore in the case of the oscillations in a condenser or coil is rightly neglected, but with very quick oscillations, as in the vibrations of light and heat, it plays a very important part. With the object of determining when this conservative damping may be neglected in the case of slow oscillations, the author has calculated it for the cases of an air-condenser and of a solenoid.

A condenser in which oscillations of definite period are excited acts at any point at a distance from the condenser which is great compared with the dimensions of the condenser but small compared with the wave-length of the electromagnetic waves, exactly as an electrostatic "Dipole" of periodically changing moment would do. This case has been investigated by the author in a former paper (Annal. Phys. Chem. 60. p. 593, 1897).

Applying the results of this former paper to the present case, the author obtains for the logarithmic decrement the expression

$$\sigma = \frac{16\pi^4 a^2 C}{3\lambda^3} = 519{\cdot}5\,\frac{a^2 C}{\lambda^3},$$

where a is the distance between the condenser-plates, C the capacity of the condenser measured in length-units, and λ the wave-length of the electromagnetic waves.

A solenoid excited by an alternating current acts at distances great compared with the dimensions of the solenoid but small compared with the wave-length of the electromagnetic waves, like a magnetic "Dipole" of periodically changing moment. The expression for the damping when applied to this case becomes

$$\sigma = \frac{16\pi^4 n^2 F^2}{3\lambda^3 P} = 519{\cdot}5\,\frac{n^2 F^2}{P\lambda^3},$$

where n is the number of turns on the solenoid, F the area enclosed by one turn, P the self-potential of the solenoid, and λ the wave-length of the electromagnetic waves in the space surrounding the solenoid. J. B. H.

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792. *Coherers affected by Sound.* **F. Auerbach.** (Annal. Phys. Chem. 64. 3. pp. 611–617, 1898.)—Metallic coherers acquire

a diminished resistance, not only by the impact of electric waves, but also by the impact of sound-waves. This is shown by placing such coherers on a table with a sounding tuning-fork not far off, with its foot on the table. The diminution of resistance is, as in the electrical case, proportional to the original resistance. Small hard-steel balls show a percentage diminution of resistance amounting to 21 by acoustic influence and 49 by the electric influence of a Righi exciter fed by two cells and giving sparks 15 cm. long. E. E. F.

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793. *Electromagnetic Screens.* **C. Maurain.** (Écl. Électr. 15. pp. 5–8, 1898.)—Cylindrical screens 22 cm. high and 5·6 cm. in external diameter, and of varying thickness, are used made of copper, brass, lead, and a zinc-copper alloy containing a few per cent. of zinc. A coil of wire, concentric with the cylindrical screen, is traversed by a sensibly sinusoidal alternating current, which produces a variable field within the screen, the intensity of which is measured by the current induced in a smaller coil placed concentrically with the larger one. The induced current is measured by a kind of electrodynamometer; the screening action is given by the ratio of the square roots of the deflections with and without the screen. Curves are given showing the decrease of this ratio as the number of alternations per second increases up to 120. With copper the decrease is rapid; with lead and brass it is small; whilst the copper-zinc alloy occupies an intermediate position. The screening action also increases with the thickness of the screen. It is finally indicated briefly that the results are in conformity with the mathematical theory. T. E.

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794. *Anomalous Electric Dispersion.* **P. Drude.** (Annal. Phys. Chem. 64. 1. pp. 131–158, 1898.)—This paper contains a mathematical discussion of anomalous dispersion, (i.) from the standpoint of general optical theory, and (ii.) on the hypothesis of molecules imbedded in a dielectric. Both methods lead to equivalent results. The formulæ arrived at, after making certain assumptions for the sake of simplicity, are

$$n^2(1-\kappa^2) = \epsilon_0 + \frac{\epsilon_\infty - \epsilon_0}{1+\left(\frac{a'}{T}\right)^2}$$

$$2n^2\kappa = \frac{\epsilon_\infty - \epsilon_0}{1+\left(\frac{a'}{T}\right)^2}\cdot\frac{a'}{T},$$

where n is the coefficient of refraction of the substance, κ its index of absorption, T the period of the incident rays, ϵ_0, ϵ_∞, and a' three constants characteristic of the substance examined.

The concluding part of the paper contains a comparison of theory with experiment for various alcohols, organic acids, glycerine, and creosote. G. B. M.

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795. *Effect of Wave-form on Capacity and Inductance Measurements.* **H. F. Weber.** (Annal. Phys. Chem. 63. 1. pp. 366–375, 1897.)—One of the simplest methods of measuring capacity and inductance is that involving the use of alternating currents. In using this method it has been customary to assume that the potential difference and current-waves are of the simple sine form. In most cases, however, this assumption is not correct. It is, then, important to determine in how far the measurement may still be considered valid. The author shows that, if the formula

$$C = I/pV$$

(where C = capacity, I = current, $p = 2\pi \times$ frequency, and V = potential difference) be used irrespective of the wave-form, then the correct value of the capacity is obtained by multiplying the above result by the correcting factor

$$f = \sqrt{\frac{1 + \frac{P_3^2}{P_1^2} + \frac{P_5^2}{P_1^2} + \ldots}{1 + 9\frac{P_3^2}{P_1^2} + 25\frac{P_5^2}{P_1^2} + \ldots}},$$

where $P_1, P_3, P_5 \ldots$ stand for the amplitudes of the simple harmonic terms into which the E.M.F. wave may be analysed (only *odd* harmonics being present). From this it is evident that a comparatively slight departure from the sine form may give rise to serious error, while with considerable distortion the error may be very large. By way of example, the E.M.F. wave of a Ganz machine ($P_1 = 100$, $P_3 = 38·4$, $P_5 = 15·6$) is quoted as giving a value of $f = 0·632$.

Dealing next with inductance measurements, the author shows that the value calculated from the formula $L = V/pI$ (the resistance assumed to be negligible) must be multiplied by the correcting factor

$$\sqrt{\frac{1 + \frac{1}{9}\frac{P_3^2}{P_1^2} + \frac{1}{25}\frac{P_5^2}{P_1^2} + \ldots}{1 + \frac{P_3^2}{P_1^2} + \frac{P_5^2}{P_1^2} + \ldots}}$$

in order to obtain the true value. This expression shows that, even with considerable deviations from the sine form, the error due to the use of the simpler formula will never be very great (the Ganz machine gives a correcting factor of 0·932). Hence the alternating-current method is more suitable for the measurement of inductances than of capacities.

The paper concludes with a criticism of a method suggested by

Stefan for ascertaining roughly whether the E.M.F. wave of an alternator departs widely from the sine form; and the method is shown to be useless, the only reliable plan being to actually determine the shape of the wave. A. H.

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796. *Graphical Study of Alternate Currents.* **C. E. Guye.** (Écl. Électr. 14. pp. 503–508, 1898.) (See Abstract 524.)—The methods of representing a sine function by means of rectangular and polar coordinates are considered; then follow the rules for the composition of alternating vectors. The graphical representation of successive differential coefficients of a sine function is next explained. In the case of any periodic function, the equivalent sine function (*i. e.* one having the same R.M.S. value) may be used to replace it. The cosine of the angle of phase-difference between any two periodic functions is defined as the ratio of their mean product to the product of their R.M.S. values. Although, so far as power is concerned, the use of equivalent sine functions furnishes correct results, yet in other instances—as, *e. g.*, the balancing of an inductance by a capacity, the determination of the greatest stress in the insulating material, or the hysteretic loss in transformers—the use of the equivalent sine function cannot be adopted. This leads to the introduction of the *form factor* of a periodic function.

The article concludes with a consideration of the composition of sine functions of different periods. A. H.

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797. *Measurement of Phase-difference.* **A. G. Rossi.** (Écl. Électr. 15. pp. 133–140, 1898.)—The method described depends on the production of a rotating magnetic field by means of the two currents whose phase-difference is to be determined. It is primarily applicable only to currents obeying the sine law. If two similar coils traversed by sine currents of equal amplitude and having a phase-difference ϕ be inclined at an angle $\pi-\phi$, then the field at the common centre of the coils will be a rotating field of constant intensity. If the amplitudes of the currents are not equal, a rotating field may still be produced, by sending the larger current through two coils—each of half the number of turns contained in the coil carrying the other current—inclined at such an angle as to render the resultant alternating field equal in amplitude to that produced by the other current. This artifice may obviously be applied to both coils at the same time, each being replaced by two half-coils inclined at a certain angle. The angles may be so chosen as to make two of the half-coils belonging to different sets co-planar. We then get the arrangement shown in Fig. 1, where A and A′ denote the planes of one set of coils, B and B′ denoting the other. It may be shown that the phase-difference is $\frac{1}{2}(\psi_1+\psi_2)$ when the resultant field is a rotating one. In order to determine this latter point, a fluorescent screen is used

on which impinges a pencil of kathode rays. The angles ψ_1 and ψ_2 are then adjusted until the orbit of the luminous patch on the screen becomes circular. The actual arrangement used by the

Fig. 1.

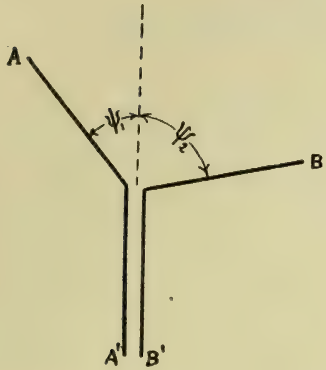
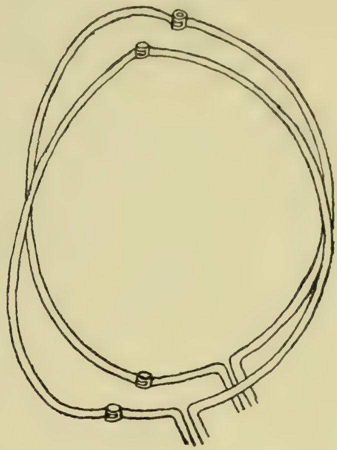


Fig. 2.



author is sketched in Fig. 2, and consists of two hinged circular conductors. The method may be extended to currents of wave-shapes not very different from a sine wave by adjusting the positions of the hinged portions of the conductors until a figure is traced out on the screen which exhibits symmetry about two mutually perpendicular diameters. A. H.

[*To be continued.*]

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798. *The Application of Imaginary Quantities to Transformer Equations.* **J. B. Pomey.** (Écl. Électr. 15. pp. 16–18, 1898.)—If $i=\sqrt{-1}$, then the locus

$$\rho=\frac{m+nx}{m'+n'x} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

is a circle, when m, m', n, n' are given imaginary quantities, and x is a variable parameter.

The locus

$$\rho=\frac{m+ne^{it}}{m'+n'e^{it}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

is also a circle, t being a variable parameter.

The transformer equations may be written

$$\left.\begin{aligned}(\mathrm{R}+p\mathrm{L}i)\mathrm{I}+p\mathrm{M}i\mathrm{I}' &= \mathrm{E},\\ p\mathrm{M}i\mathrm{I}+(\mathrm{R}'+p\mathrm{L}'i)\mathrm{I}' &= \mathrm{O},\end{aligned}\right\}, \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where R, L, I are the resistance, self-induction, and current in the primary circuit; R′, L′, I′ corresponding quantities for the secondary circuit; E the primary impressed potential difference; and $p=2\pi n$, n being the frequency of the currents.

From equations (3) we get

$$p\mathrm{M}i\mathrm{I}' = \frac{\mathrm{E}}{1+\frac{\sqrt{\mathrm{R}^2+p^2\mathrm{L}^2}\sqrt{\mathrm{R}'^2+p^2\mathrm{L}'^2}}{p^2\mathrm{M}^2}\cdot e^{i(\alpha+\beta)}},$$

where

$$\tan\alpha = \frac{p\mathrm{L}}{\mathrm{R}}, \quad \tan\beta = \frac{p\mathrm{L}'}{\mathrm{R}'}.$$

Thus, by (2), the vector

$$\rho = p\mathrm{M}i\mathrm{I}'$$

describes a circle.

If we consider the vectors OA=E and OB=pMiI′, we get

$$\frac{\mathrm{BA}}{\mathrm{OB}} = ke^{(\alpha+\beta)i},$$

where

$$k = \frac{\sqrt{\mathrm{R}^2+p^2\mathrm{L}^2}\sqrt{\mathrm{R}'^2+p^2\mathrm{L}'^2}}{p^2\mathrm{M}^2},$$

which shows that the ratio of the lengths of BA and OB is equal to k, and that the angle between the two vectors is $\alpha+\beta-\pi$.

The point B is, if the vector OA is given, the intersection of the following circles:—First, the locus of points such that the ratio of their distances to the points O and A equals k; and, second, the locus of points at which OA subtends an angle $\alpha+\beta-\pi$.

W. G. R.

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799. *Theory of Alternating Currents.* **W. G. Rhodes.** (Roy. Soc. Proc. 62. pp. 348–349, 1898.)—This paper is divided into two parts. Part I. deals with the determination of equivalent impedances of multiple circuits and generally with the complete investigation of complicated arrangements of mutually dependent circuits. The method adopted depends upon the fact that if a simple harmonic function is differentiated twice in succession, the result is proportional to the original function.

Part II. considers the effect of harmonics in alternating current circuits. It is shown that any periodic E.M.F.'s and corresponding currents can always be represented by simple sine curves having the same root mean square values, and suitable phase positions depending only on the time constants of the circuits and on the periodicities of the harmonics present. AUTHOR.

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800. *Electrodynamometer in Shunt.* **M. Wien.** (Annal. Phys. Chem. 63. 1. pp. 390–394, 1897.)—Let the resistances and self-inductions of the shunt and dynamometer circuits be respectively

r_1, L_1 and r_2, L_2; the frequency n, the dynamometer constant k, and its deflection d.

The author deduces a general value of the dynamometer deflection for any current in terms of the amplitudes of its sine components. This depends on the frequency and is complex, reducing itself, however, in the particular case when $L : L = r : r$ to the formula, for sine currents,

$$[\text{Effective current}]^2 = dk^2 \frac{[r_1 + r_2]^2}{r_1^{\ 2}}.$$

To obtain this condition the dynamometer and shunting resistance are joined up in a Wheatstone Bridge with adjustable resistances r_3 and r_4. r_1 and r_3/r_4 are varied until balance is obtained, employing alternating currents and telephone. Then $r_1 : r_2 = L_1 : L_2 = r_3 : r_4$, giving at once the required condition and the shunt ratio. By providing a dynamometer with special shunting-coils satisfying these conditions, an enormous range may be given to the instrument. In the case of an approximately sine current, if $L_1 = 0$ and $n^2L_2^{\ 2}$ is large compared with $r_2^{\ 2}$, a condition satisfied by inserting inductive coils in the dynamometer circuit, the divergence from a true sine current becomes negligible, and

$$\text{Effective current} = \frac{k}{r_1} \cdot \sqrt{d\{[r_1 + r_2]^2 + n^2L_2^{\ 2}\}}.$$

A dynamometer employed in shunt must be free from iron and large metal pieces, so that its inductance is independent of the frequency. G. H. Ba.

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801. *Lecture-room Galvanometer.* **R. W. Quick.** (Amer. Electn. 10. p. 166, 1898.)—The paper describes a lecture-room galvanometer which, while having a suspended magnetic system, does not require the special lantern necessary with a mirror-galvanometer, but can be used in the ordinary projection lantern, provided this has a vertical attachment. The coil has a horizontal axis in which an aluminium pointer is suspended. Below this is a horizontal glass plate with a scale of tangents, through which the light is transmitted vertically and then reflected. G. H. Ba.

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802. *Quadrant Electrometer.* **J. Elster** and **E. Geitel.** (Annal. Phys. Chem. 64. 4. pp. 680–684, 1898.)—The drying apparatus attached to the quadrant electrometer designed by the authors is a piece of sodium attached to a wire which is mounted in a side tube off the chamber containing the quadrants. The damping liquid is petroleum, contained in a vessel with a ground-glass edge which presses against the rubber-padded inner edge of the main chamber. It is both air-tight and easily removed. The improved electrometer has a very constant zero. E. E. F.

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803. *Electric Arc.* **A. Hess.** (Écl. Électr. 15. pp. 49–51, 1898.)—This article gives an account of recent research on the electric arc. C. K. F.

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804. *Annular Standard of Inductance.* **I. Fröhlich.** (Annal. Phys. Chem. 63. 1. pp. 142–153, 1897.)—Describes a shape of standard which allows of an exact geometrical calculation of its value. It consists of a ring of Carrara marble of rectangular section, wound with a single layer of a fine insulated copper wire in 2738 turns. The ring is divided into two halves, each of which, being of a semicircular shape, can be connected independently. The shape is accurately measured by the cathetometer. The self-induction of such a ring is given by the equation

$$L=2n^2h\log_e\frac{r_2}{r_1}$$
$$-2n^2h\,.\,0{\cdot}28721\left[\rho\left(\frac{1}{r_1}+\frac{1}{r_2}\right)+\frac{2\rho}{h}\log_e\left(\frac{r_2}{r_1}\right)\right],$$

where r_1, r_2 are the internal and external diameters of the ring, h its thickness, ρ the radius of the wire, and n the number of turns. The value experimentally found does not differ from the calculated value by more than $\frac{1}{5}$ per cent. E. E. F.

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805. *Standard Resistances of the Reichsanstalt.* **W. Jaeger** and **K. Kahle.** (Annal. Phys. Chem. 64. 3. pp. 456–485, 1898.)—This paper deals fully with the construction and calibration of the Reichsanstalt standards. It describes the geometrical measurement of the tubes containing the mercury standards, the weighing of the mercury contained in them, the calculation of the resistance, and allowance for the extension resistance where the narrow standard tubes join the terminal bulbs. Further, it describes the method of copying the standard tubes and comparing them among each other and with manganin-wire resistances. When filled in a vacuum, the resistances of several successive fillings need not differ by more than a few 100,000ths of an ohm, and the secular change in four or five years is of the same order, as is also the secular change of the manganin resistances. E. E. F.

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806. *Electrical Alloys.* **R. Appleyard.** (Elect. Rev. 42. pp. 536–537, 1898.)—This is the first of two articles on alloys used for various electrical purposes. It is almost entirely a translation from Vol. ii. of the 'Wissensch. Abhandl. d. P. T. Reichsanst.' German silver, nickel, and "patent nickel" are examined as to their *chemical constitution*, *specific resistance*, and *thermo-electric power against copper*. The effect of *rolling*, as regards change of resistance, is also tabulated for various alloys. If the diameter of the roller is 40 times that of the wire, only a very small increase in the resistance of "patent nickel" is observed; with German

silver the increase is about four times greater. If rollers 10 times the diameter of the wire are used, both alloys show a change of resistance of about four times the above amount; this is attributed partly to stretch and partly to hardening. The *quasi-permanent changes of resistance due to heating* are examined by submitting specimen resistance-coils for several hours in thermostats at 40° C., 100° C., and 150° C. successively, and then again at 100°, measuring the resistance before and after each heating. It is thus proved (1) that the specific resistance of German silver and nickelin can be made approximately constant by prolonged heating at 150° C., and (2) that the specific resistance of patent nickel becomes constant under the same treatment, so that it does not undergo subsequent change even when heated to 100° C. Reference is also made to similar work done by Klemenčič. AUTHOR.

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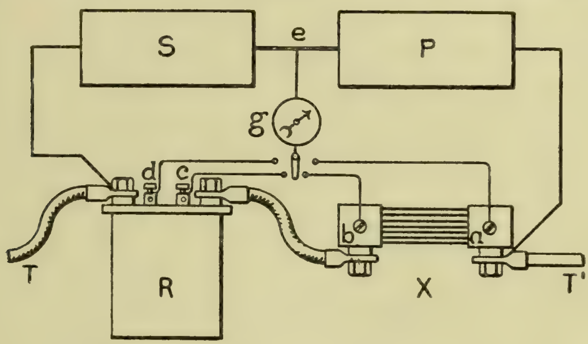
807. *Comparison of very Small Resistances.* **S. Sheldon.** (Elect. World, 31. p. 296, 1898.)—The unknown resistance X (see figure) which may be assumed to be supplied with branch potential points *a*, *b*, is connected by heavy conductors in series with a standard branch resistance R, of the Reichsanstalt pattern, having potential points *c*, *d*. From the two free terminals, TT′,



of these resistances are shunted two 10,000 ohm resistance-boxes S, P, adjusted to the same normal temperature and wound with wire of the same or negligible temperature coefficient and connected in series. From the point of connection *e*, between the two boxes, is connected one terminal *g* of a sensitive d'Arsonval galvanometer, the other terminal being successively connected with the potential points *a*, *b*, *c*, and *d*. At first all the plugs are removed from the box S, and all are in place in the box P. After connecting T and T′ with a source of heavy current, plugs are transferred from one box to the corresponding holes in the other box, keeping the total resistance in the two boxes constant until no deflection is observed in the galvanometer. This operation is repeated for each of the potential points *a*, *b*, *c*, *d*. Representing the resistances in the box S corresponding to each of these balances by S_a, S_b, S_c, and S_d

respectively, we have for the unknown resistance the expression

$$X = \frac{S_a - S_b}{S_c - S_d} \cdot R.$$

W. G. R.

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808. *Electrical Properties of Glass.* **A. Gray** and **J. J. Dobbie.** (Roy Soc. Proc. 63. pp. 38–44, 1898.)—The experiments described are the first instalment of work undertaken by the authors with a view to determine the circumstances which affect the conductivity and specific inductive capacity of glass. Previous experimenters have shown that potash and soda-lime glasses have a higher conductivity than flint glasses. It seemed desirable to ascertain whether by increasing the amount of lead-oxide and diminishing the amount of soda, the conductivity would go on diminishing. From manufacturers in London and Jena various specimens of glass were obtained, all richer in lead than those formerly available, and, further, in some cases practically free from soda. Specimens of glass used for thermometers and a barium crown glass were also tested. The method of determining the *conductivity* was the same as that adopted in previous experiments described in Proc. Roy. Soc. No. 231, 1884. When the glass admitted of it, the specimen was used in the form of a flask: this was filled up with mercury to the bottom of the stem, and the flask thus filled was sunk in a bath also containing mercury, so that the mercury was at the same level inside and outside. One terminal of a circuit containing a battery of about 30 secondary cells and a very sensitive galvanometer was connected to the mercury within the flask by a wire passing down the neck, while the other terminal was connected to the mercury in the bath. The galvanometer was carefully insulated, as was also the reversing key, and all necessary precautions were taken to make sure that the current passing through the galvanometer was that passing through the walls of the flask between the mercury coatings.

In the *capacity* measurements the glass was in the form of a plate or flask. A quadrant electrometer was kept connected to the plates of one of Lord Kelvin's air-leydens. This was charged to a potential difference of about 24 volts by means of 12 secondary cells. After the battery had been removed, a reading was taken of the electrometer deflection, and then the specimen was connected for a very short time as a condenser in parallel with the leyden. The connection was made by means of a myograph pendulum, which, when freed, swung over a considerable arc to a catch which prevented it from returning. The arrangement was such that the interval of time during which the connection between the two condensers endured was reckoned as at most about 1/30,000 of a second.

The plates were originally rather over $\frac{1}{4}$ in. thick, and after some observations of capacity had been made and it had appeared that their resistance was too great to be measurable, the thickness was reduced by cutting and grinding to about 0·24 cm. After polishing

and cleaning, they were covered on both sides with a dense and thoroughly adherent coating of silver. This was cut away for a space of about ½ in. round the edges; care being taken to remove every trace of silver and to make the edge thoroughly clean. The glass plate was laid with one coating of silver resting on a plate of copper at the bottom of an iron bath. Another plate of copper was laid on the upper coating of silver and kept down with a weight, and the connections of the battery circuit described above were made with the copper plates. The iron bath was placed within a larger bath partly filled with sand, so that the temperature could be raised by heating the outer bath from below. The results of the experiments are given in a table, which states the density, specific resistance, specific inductive capacity, and chemical composition of each specimen experimented on. The following extract from the authors' table gives some particulars of the results they obtained with the four specimens of glass they used:—

Description of glass.	Density.	Specific Resist. (ohms).	Sp. ind. cap.
Lead-potash glass (Powell, London).	3·495	Too high to measure: above $18{,}000 \times 10^{10}$ at 130° C.	7·966 at 15° C. 7·630 at 120° C.
Lead-potash glass (Schott & Co., Jena).	3·591	Too high to measure: above $35{,}000 \times 10^{10}$ at all temps. to 135° C.	7·991 at 14° C.
Barium glass (Schott & Co., Jena).	3·565	Too high to measure; above $59{,}000 \times 10^{10}$ at all temps. to 140° C.	8·5. No variation with temperature. No absorption effect.
Zinc-soda "Jena glass" (Schott & Co.).	3·493	$596{\cdot}5 \times 10^{10}$ at 43° C. $0{\cdot}200 \times 10^{10}$ at 140° C.	7·54 at 15° C. Conduction too great at high temps.

The resistance was taken after 5 mins. electrification in each case. The "Jena glass" (No. 4 above), both in resistance and capacity experiments, showed very considerable effects of dielectric polarisation, which took a long time to disappear. The same was true of Powell's lead glass. On the other hand, the barium glass in the capacity experiments showed little or no sign of polarisation effects. This glass has a very high resistance, and in this respect behaves more like lead than lime glasses, which have usually low resistance. The "Jena glass" has a low resistance, as was to be anticipated from its high percentage of soda and complex composition. Experiment points to the conclusion that a glass which approaches in composition to a definite chemical compound has a high resistance. J. J. S.

809. *Electrical Resistance of Metals.* **C. Liebenow.** (Zeitschr. Elektrochem. 4. pp. 201–211, and pp. 217–227, 1897.)—If a large number of thin alternate plates of two different metals are pressed together and a current passed through the pile, heat will be absorbed, say, when the current passes from metal M_1 to metal M_2 and evolved when it passes from M_2 to M_1. Owing to the differences of temperature thus produced at the junctions a counter-E.M.F. will be developed, equivalent to an apparent increase of resistance. Assuming that the plates are so thin that the differences of temperature are always small, this E.M.F. is found to be represented by the equation

$$E=rc,$$

where c is the current and

$$r=\frac{n(1-n)}{a(1-n)+bn}\frac{l}{q}f(T), \quad \ldots \ldots \quad (1)$$

n being the part of the total length consisting of the one metal, $(1-n)$ the corresponding fraction for the other metal, l and q the length and cross-section of the pile, $f(T)$ a function of the temperature, and a and b the specific conductivities of the two metals for heat. This equation is true whether the plates are of equal thickness or not. The author considers that a metal containing dissimilar molecules would be equivalent to such a pile, and its resistance would be equal to the sum of the resistances of the metals together with an extra part due to the thermo-E.M.F. above considered.

Calling A_0 the sum of the resistances of the pure components, B_0 the extra resistance, and C_0 the specific resistance of the alloy, all at 0°, we have

$$C_0=A_0+B_0, \quad \ldots \ldots \quad (2)$$

or at $t°$

$$C_0(1+\gamma t)=A_0(1+\alpha t)+B_0(1+\beta t). \quad \ldots \ldots \quad (3)$$

For pure metals $\alpha=0{\cdot}004$ approximately, and for a cube of unit side

$$B_0=\frac{n(1-n)}{a(1-n)+bn}f(T_0),$$

where a and b are now the internal heat conductivities of the molecules. B_0 is a maximum for $n=1/1+\sqrt{\frac{b}{a}}$. The positive root alone gives possible values for n (viz. between 0 and 1), so that there is only one such maximum.

From (2) and (3),

$$\gamma=\frac{A_0\alpha+B_0\beta}{C_0}. \quad \ldots \ldots \quad (4)$$

According to Matthiessen the conductivities of the alloys of certain metals are the mean of those of the components, the quantities

of the latter being calculated as volumes. In these cases $B_0=0$, and therefore $\gamma=\alpha$. That is, the resistances of the alloys have the same temperature coefficient as pure metals, which is in accordance with the facts. Another group of alloys has smaller conductivity than the mean of the conductivities of the components, and in this case Matthiessen finds the following relation to hold:

$$A_0 - A_0(1+100\alpha)=C_0 - C_0(1+100\gamma),$$

from which

$$\gamma=A_0\alpha/C_0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Comparing this with (4) it follows that in this class $\beta=0$, which would be true if $f(T)=\text{const}$. Making this assumption, it is shown that equation (2) is capable of accurately representing Matthiessen's results with alloys of gold with copper or silver; the values of a, b, and $f(T)$ are calculated from the observations. In the case of some alloys of nickel and copper studied by Feussner, which have a negative temperature coefficient, β must have a negative value.

If the two metals (M_1 and M_2) combine to form a compound, there will be a series of alloys containing molecules of M_1 and of the compound, then the pure compound, and finally a series containing compound molecules and molecules of M_2. In the pure compound the thermo-E.M.F. must disappear, since the molecules are all identical, and the temperature coefficient should be equal to that of the pure metals; for the alloys containing excess of one or other of the component metals the temperature coefficients are smaller. The curve representing the connection of temperature coefficient and composition has therefore a maximum corresponding to the composition of the compound. Similar considerations hold for the resistance. This, the author considers, is the first reliable method proposed for determining whether an alloy is a true compound or merely a mixture. Zinc and copper appear to form the compound CuZn. In pure metals the molecules move with different velocities, that is they have different temperatures. Owing to these temperature differences a current passing through the metal gives rise to an opposing E.M.F. in the same way as in the thermopile, except that groups of identical molecules at different temperatures take the place of the heterogeneous molecules. The mathematical treatment is practically the same. The paper concludes with some remarks on thermo-electromotive forces, and on the interesting properties of true compounds of the metals, for which the original must be consulted. T. E.

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810. *Thermo-electric Currents.* **Bakhmetieff, Christodulus, and Georgieff.** (Écl. Électr. 15. pp. 81–85, 1898; Journ. Soc. Phys. Chim. Russe, 29. p. 14.)—The authors melt tin in a porcelain capsule into which are plunged wires connected to a galvanometer; the capsule is placed in a chamber which can be surrounded at pleasure by ice. The authors find that there is an E.M.F. in the

circuit which remains practically constant as the tin solidifies and then diminishes. This E.M.F. is greater the lower the temperature of the chamber. When the chamber is not surrounded by ice the temperature of the solidifying tin is 220° C., the average of the surrounding chamber during the whole time of solidification 85° C., and the E.M.F. 49·9 microvolts. With the chamber surrounded by ice the figures are 218°·5 C., 54°·5 C., and 103·2 microvolts. The authors have also experimented with a tin-cadmium alloy. E. C. R.

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811. *Change in the Zinc Sulphate in Clark Cells.* **W. Jaeger.** (Annal. Phys. Chem. 63. 1. pp. 354–365, 1897.)—Ordinary crystalline zinc sulphate which is represented by the formula $ZnSO_4+7H_2O$, changes at 39° C. to $ZnSO_4+6H_2O$, giving up a molecule of water. These two different forms possess different solubilities, and Clark cells made up with the two forms would have different electromotive forces and different temperature coefficients. It thus follows that at 39° C. there is a sharp bend in the temperature-coefficient curve of a Clark cell. The present author has succeeded in tracing that part of the curve above 39°, which corresponds to $ZnSO_4+6H_2O$, down from 39° to 0° C. By repeated warming to 50° or 60° C. and slow cooling, the sulphate did not change back again into the ordinary form, so that the electromotive force due to the anomalous sulphate was measured at all temperatures down to 0° C. The electromotive force of such a cell at about 15° C. is less than that of the ordinary Clark cell by ·7/1000. On dropping a crystal of normal sulphate into the cell, the transformation to the normal form takes place very quickly with a return to the normal electromotive force. The paper, which emanates from the Reichsanstalt, contains a number of tables of results and diagrams showing the difference between the appearances of the cells in the two states, the ordinary and the anomalous. J. B. H.

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812. *Temperature Measurements in Electrolytic Cells.* **F. Richarz** and **W. Ziegler.** (Annal. Phys. Chem. 63. 1. pp. 261–267, 1897.)—It was shown several years ago by one of the authors that the temperature of a small electrolytic cell surrounded with ice does not approximate to 0° throughout, as is often tacitly assumed, but in the neighbourhood of the electrodes, especially when the latter are relatively small, rises enormously as the current is increased, and eventually, near the boiling-point of the electrolyte, gives rise to a phenomenon analogous to Leidenfrost's spheroidal state. The results of a series of exact experiments on the subject are now given. The experimental cell consists of a test-tube 7 cm. × 24 mm. diam., which is surrounded with crushed ice and filled with 20 % sulphuric or nitric acid as electrolyte. One electrode is a cylinder of platinum-foil fitting within the tube, whilst the other, at the surface of which the temperature is to be

measured, is a platinum wire passing down the axis of the tube. Attached to this wire but insulated from it by a glass capillary sleeve 3 mm. long, is a platinum-platino-iridium couple. The strength of the current being raised by regular increments of 0·5 ampere, the temperature is read off at each stage as soon as it is constant; it is found to rise steadily as the current increases, until, at a few degrees below the boiling-point of the electrolyte, the spheroidal phenomenon sets in. The distribution of temperature in the cell is mathematically discussed, and the experimental results are found to agree with the calculated as closely as can be expected, seeing the uncertainty of some of the data involved. It is pointed out that the heating at the electrode notably diminishes the resistance of the cell, and that determinations of E.M.F. of polarisation in which the resistance is assumed constant may consequently be seriously affected: an error of as much as 2 volts may in fact be thus introduced. J. W.

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813. *Thermo-electric Batteries and the Jacques Cell.* **W. A. Anthony.** (Amer. Electn. 9. pp. 431–432, 1897.)—In continuation of the discussion (see Abstract No. 658) Anthony states that in his opinion some of the oxygen goes into solution or in some other way comes into electrical connection with the iron electrode, and combines with the positive ion in strict accordance with Faraday's law. In support of this statement, he has found that more oxygen bubbles through on open circuit than on closed circuit, and the current falls to a low value *immediately* on stopping the flow of gas. The same sort of thing occurs in the Grove gas battery, and there is no difficulty in regarding the oxygen as a depolariser, just as in two-fluid cells, although not a compound. The source of energy omitted by Reed in calculating the E.M.F. is the union of oxygen with the positive ion. The reaction is

Iron.		Carbon.
	Before.	
	$2O + 3KHO + C$	
	After.	
	$\left.\begin{matrix} KHO \\ H_2O \end{matrix}\right\} + K_2CO_3$	

C. J. Reed (Amer. Electn. 9. pp. 432–433, 1897) denies that the oxygen which combines with the positive ion does so in accordance with Faraday's law. It is simply a case of combustion. As the oxygen and the oxidised body are not connected by any electric conductor other than the electrolyte, the reaction cannot evolve electrical energy. The only possible sources of energy are (1) the energy of carbon oxidised within the cell, (2) the heat energy evolved within the cell by the oxidation of reduced ions, (3) the heat energy absorbed from without. The reaction suggested by Anthony, viz.:

$$2O + 2KOH + C = H_2O + K_2CO_3,$$

does not take place, the formation of carbonate being incidental and subsequent to that of CO_2.

Elihu Thomson (Amer. Electn. 9. p. 476, 1897) states some facts with regard to the Jacques cell. CO_2 does not escape when the cell is in action, but produces alkaline carbonates from the hydrate, oxygen, and carbon. An equivalent supply of hydrate is therefore required. The formation of carbonate goes on whether the circuit be opened or closed, but stops when the oxygen is stopped, indicating direct combination of oxygen with hydrate or carbon. The Jacques cell probably resembles a copper–sulphuric–acid-carbon cell to which an oxidising agent is added. Copper sulphate is formed whether the circuit is closed or open, but the cell is nevertheless capable of giving a current. In fact a great deal of local action is taking place. Now replace the copper by carbon, the sulphuric acid by caustic soda, and the carbon by iron: we then have the Jacques cell. The energy may all appear as heat within the cell, or partly as electric energy in an external circuit.

W. A. Anthony (Amer. Electn. 9. pp. 476–477, 1897) complains that Reed does not fairly interpret his statements. He agrees with Thomson's views. The fact that carbonate is formed at nearly the same rate whether the circuit is open or closed, shows that an enormous amount of local action takes place. This is certain to be so if the stream of oxygen is allowed to flow against the carbon. To avoid local action, the oxygen should be carefully kept away from the carbon just as a depolariser in two-fluid cells is kept away from the zinc. If this were done, the carbonate formed would probably be found to be nearly the equivalent of the current. His own experiments show that much more oxygen is consumed on closed than on open circuit when it is kept away from the carbon.

W. Ostwald (Amer. Electn. 10. pp. 16–17, 1898) compares the Jacques cell to a Lalande cell. The latter becomes exhausted as soon as the copper oxide is all reduced, but might be again rendered active by blowing a stream of oxygen on to the copper. In the Jacques cell the place of the copper oxide is taken by ferric oxide or sodium ferrate. The only active substance is the absorbed oxygen, the energy set free by the union of the oxygen with the copper or the iron being lost as far as the electrical process is concerned. There is no way known as yet for preventing this loss, or of directly utilising the chemical potential of free oxygen on a commercial scale. The difficulty in obtaining electricity from coal rests, on this account, more with the oxygen than with the coal. In the Jacques cell the oxygen is only required at the kathode: any that reaches the coal and burns it directly only gives rise to local action. The formation of ferrate may be neglected in any calculation of E.M.F. because it may be assumed that just as much ferrate is re-formed by the oxygen as is decomposed by the current. Consequently the only reaction to be considered is

$$2NaOH + C + O_2 = Na_2CO_3 + H_2O.$$

The E.M.F. equivalent to this is 2·66 volts, assuming the heat of reaction to be the same as at ordinary temperatures.

C. J. Reed (Amer. Electn. 10. pp. 17–20, 1898) remarks that he has apparently given Jacques credit for more than he deserves. It has been stated that the greater part of the CO_2 escapes without combining with the caustic soda. But from the statements of Thomson and Anthony it now appears that an equivalent of caustic soda is required. The total efficiency of 32 °/₀ as given by Jacques therefore drops to 24 °/₀; and if two-thirds of the energy is required to operate the air-pump, as stated by J. H. Helweg, jun., this figure falls to 8 °/₀. Coming to cost, the raw material for the Jacques battery will cost at least thirty-four times that for a good steam-engine, and the residue will weigh ten or twelve times that from the boiler. The whole question of the theory of the cell depends upon the function of the oxygen forced into it. There is no possibility of galvanic action without the energy evolved by oxidation. That the action is thermo-electric is sufficiently supported by the fact that if iron is substituted for the carbon, a still higher E.M.F. results, without a stream of air, both electrodes being iron in that case. The idea that free oxygen can act as a depolariser is a mistake; it must be in combination. Free oxygen with a platinum electrode acts as a depolariser because, as Berthelot pointed out, the platinum combines with the oxygen. That is not the case with carbon. He agrees with Ostwald that the function of the oxygen is to reoxidise the reduced iron, and that the energy of this reaction is lost as far as any electrical process is concerned. Why the reduction of the oxide should be omitted by Ostwald in calculating the E.M.F. is not clear. It should be included just as well as the reduction of copper oxide in the Lalande cell. The continuous renewal of the ferrate is no reason why this part of the reaction should be omitted. In the calculation of the E.M.F. as given by Ostwald, the result should be 1·33 volts instead of 2·66, carbon being tetrad. If the reduction of ferric oxide is taken into account in calculating the E.M.F., the result is negative, showing that such a reaction cannot be galvanic. The correctness of these views is shown by an experiment carried out by the author with a silver crucible. Metallic sodium was given off from the walls of the crucible. The liberation of sodium increased continuously after alloying with the silver, notwithstanding the fact that a strong blast of air was forced through the cell. Twenty minutes after closing the circuit the E.M.F. had fallen to zero and reversed, and in thirty minutes the explosions were so violent that the experiment had to be stopped. The crucible was found to have formed a porous alloy with the sodium.

W. A. Anthony (Amer. Electn. 10. pp. 63–64, 1898) disputes Reed's statements with regard to the depolarising action of oxygen. It is not an accepted fact that oxygen combines with a platinum electrode. The view generally held is that it is condensed upon the surface. Similar results are obtainable with carbon. An inert gas, or vibration, does not have the same effect. With regard to

the action of two iron electrodes at different temperatures in caustic soda, it is questionable if they would, as stated by Reed, indefinitely maintain an E.M.F. of 1·2 volts so long as the temperature is maintained.

J. Thomsen (Amer. Electn. 10. p. 64, 1898) believes that the action is galvanic. Taking the equation,

$$C + 2NaOH + O_2 = Na_2CO_3 + H_2O,$$

the heat corresponding to this amounts to 133,440 calories. To determine how much of this is available, three possibilities must be considered:—(1) The oxygen may combine direct with the carbon; (2) the oxygen may form oxide of iron which is again reduced by the current; (3) the oxygen may be occluded by the iron or caustic soda before the reaction takes place. No cases are known in support of the first. The second cannot be adopted, as there would be no resulting evolution of heat on the total reaction. It is, therefore, reasonable to suppose that the oxygen is occluded. Ramsay, Mond, and Shields have found the heat of occlusion by platinum to be 17,600 calories. Assuming that of iron to be about the same, the heat of reaction amounts to 133,440 – 35,200 calories, and the E.M.F. to 1·07 volts.

C. J. Reed (Amer. Electn. 10. pp. 109–110, 1898) remarks that, according to Thomsen's statements, the action of the Jacques cell is thermo-electric unless oxygen is occluded by the iron. There is, however, no evidence in support of the view that iron at 500° C. will occlude oxygen. He also criticises the experiments of Anthony upon the depolarising power of oxygen.

It is not possible to refer in an abstract to all the various points raised in this discussion. W. R. C.

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814. *Disturbing Action of Electric Currents on Magnetometers.* **C. H. Davis.** (Écl. Électr. 15. pp. 27–28, 1898; Terrestrial Magnetism, 11. p. 125, 1897.)—The photographic records of the magnetic elements at the Washington naval observatory are affected to a marked degree by the working of an electric tramway passing within about 425 m. of the observatory. The disturbance amounts to an increase of 15×10^{-6} dyne in the value of the vertical component when a single car is running, and reaches 300×10^{-6} dyne at times of heavy traffic; a short circuit caused a diminution of 1500×10^{-6} dyne, lasting for $1\frac{1}{2}$ hours. The rails were rebonded, and joined to the neighbouring water- and gas-pipes, without effect. Another tramway, 1200 m. distant, produces appreciable disturbances, as well as an arc-lamp circuit with earthed return in the town. The magnetic observations at the Toronto observatory, situated within 215 m. of an electric tramway, have had to be discontinued. The least distance at which the effect of the currents becomes negligible is 2 miles: it is suggested that earthed returns should be forbidden in the vicinity of magnetic observatories. A. H. A.

815. *Magnetisation of Cylinders.* **L. Holborn.** (Berlin. Akad. Sitzber. 10. pp. 159–168, 1898.)—The author investigates the situation of the poles in a magnetised iron cylinder under various circumstances. The apparatus consists of two coils, one of which is very short, so that all the lines of force pass through its open ends without loss, while the other is so long that all the lines of force penetrate the turns of the coil. The effective length of the magnet is then obtained from the induction impulses in the two coils produced by the magnetisation of the cylinder. The results for total magnetisation show that the distance between the two poles of a cylindrical magnet 15 cm. long varies between 10·8 and 13·7 cm., or between 0·72 and 0·91 per cent. of the total length. As the field increases in force the distance between the poles decreases at first. The minimum coincides with the maximum of magnetic susceptibility. After that is passed, the distance between the poles increases. E. E. F.

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816. *Magnetic Shielding.* **H. du Bois.** (Annal. Phys. Chem. 63. 1. pp. 348–353, 1897.)—The subject of magnetic shielding becomes every day more important owing to the great developments which are taking place in electric traction, and the consequent increase in the number of disturbing influences which affect galvanometers and other magnetic measuring instruments. The author in the present paper gives a *résumé* of the past work on the subject, and then proceeds to a theoretical investigation of the shielding produced by two concentric spherical shells and by two concentric cylindrical shells of ferromagnetic material on the internal space. An expression is deduced for the shielding effect, and the author proposes to discuss the results in a future paper.

[This paper appeared in English as the first of a series on Magnetic Shielding by the same author in the 'Electrician,' vols. 40 and 41, 1897–8.] J. B. H.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

817. *Absorption of Gases by Mercury and Amalgams.* **C. Christiansen.** (Annal. Phys. Chem. 62. 4. pp. 545–568, 1897.) —This investigation was undertaken with a view to discover the cause of contact electricity, and the paper has this for its title. It contains tables giving the results of experiments on the absorption of gases by mercury and by a large number of amalgams, but most experiments were made with zinc amalgam. The mercury and amalgams were caused to flow through a fine nozzle in the bottom of one vessel, then drop through an atmosphere of the gas into another vessel. The whole apparatus was enclosed so that the same atmosphere filled both vessels, and the absorption was measured by the loss of gas in this atmosphere as registered on a manometer. Only oxygen and water-vapour seem to be absorbed. The absorption is independent of the strength of the amalgam and of the pressure of oxygen. J. B. H.

818. *Vapour-Pressures of Dilute Solutions.* **C. Dieterici.** (Annal. Phys. Chem. 62. 4. pp. 616–643, 1897.)—The paper contains first of all a discussion of the results of experiments by different physicists on the freezing-points of dilute solutions, showing that the latest and most trustworthy results, namely those of Loomis and Ponsot, do not support Arrhenius' theory, but rather contradict it. The present experiments were undertaken to test the accuracy of the theory with regard to the vapour-pressures. The apparatus used consists of three small vessels to hold respectively water, a standard solution, and the solution whose concentration is varied. The difference in the vapour-pressures is measured by the deflection of a flexible membrane which forms part of the wall dividing another vessel into two compartments, one of the compartments being in connection with, say, the water-vessel, and the other compartment with, say, the standard solution. The difference in the vapour-pressures of the standard solution and water is obtained from this deflection, and similarly the difference between water and the other solution; the difference between the two solutions then acts as a check on the other two. The deflections of the membrane were obtained by a magnifying arrangement of mirror, telescope, and scale, and were standardised in mms. of mercury.

The results are given in tabular form for a large number of electrolytes and non-electrolytes. In all the experiments, with decrease of concentration from n to 0·1 n (where n represents 1 grm.-molecule per 1000 grms. of water), there was a decrease in the molecular vapour-pressure, whereas the dissociation theory indicates an increase. If the electrolytic conductivity therefore is to be explained on the dissociation theory, we must assume either

that the variation of vapour-pressure is not to be explained on the same hypothesis, or that there is some other influence at work which makes the expected increase of pressure into a decrease. The experimental results agree qualitatively very well with those of Loomis and Ponsot on the lowering of the freezing-point. In Raoult's formula for the vapour-pressures,

$$\frac{p_w - p_s}{p_w} = c\,\frac{S}{W+S},$$

where S and W are respectively the number of molecules of solute and solvent, and c is a constant, Raoult gave the value of c for non-electrolytes as approximately unity. The present author now finds that c is not a constant, but is to some extent dependent on the nature of the solute and solvent. J. B. H.

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819. *Absorption of Gases by Liquids.* **C. Bohr.** (Annal. Phys. Chem. 62. 4. pp. 644–651, 1897.)—Up till now no simple relationship has been discovered between the amount of gas absorbed by a liquid and the temperature. In the present paper, by comparing the experimental results of Winkler, Timofejew, Bohr and Bock, Carius and Bunsen, the author has shown that the formula

$$a(T \sim n) = \kappa$$

is closely satisfied between certain temperature limits. Here a is the volume of gas, measured at N.T.P., absorbed by 100 c.c. of liquid at the absolute temperature T; κ and n are constants which vary with the gases. The agreement between the numbers calculated for a from this formula and those obtained by experiment is very close up to about 50°–60° C., at which point the curve expressing aT as a function of a bends considerably away from the straight-line form which it maintains up to that point. With the gases H, N, CO, NO, and O the square root of the molecular weight is a straight-line function of the constant n, the relation being expressed by the equation

$$\sqrt{M} = n \cdot 0{\cdot}04968 \sim 6{\cdot}286.$$

J. B. H.

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820. *Diffusion Coefficients.* **W. Seitz.** (Annal. Phys. Chem. 64. 4. pp. 759–777, 1898.)—These are determined by Weber's electrolytic method. Plates of zinc are separated by a glass ring containing zinc sulphate solution. The solution is partly electrolysed, which produces a gradation of density between the plates. This gradation is subsequently obliterated by diffusion, and the progress of diffusion is observed by the diminution of the counter E.M.F. of the combination. This method reduces the time required from several days to as many hours. A difficulty lies in allowing for the irregular initial difference of potential between

plates containing a solution of zinc sulphate of uniform strength; but the author eliminates this by noting the apparent diminution of the diffusion coefficient as the experiment proceeds. The following are some of the diffusion coefficients obtained, in cm^2/ days:—

Zinc sulphate 0·312 g/cm^3......	0·1162
,, normal..........	0·2355
Zinc acetate, double normal	0·1195
Zinc formate, half normal	0·4654
Cadmium sulphate, double normal	0·2456

Experiments with lead, silver, and tin salts yielded indecisive results. E. E. F.

821. *Optical Properties of Silicium Compounds.* **G. Abati.** (Zeitschr. phys. Chem. 25. pp. 353–364, 1898.)—The study of the refractive index and dispersive power of silicium compounds is interesting on account of their analogy with carbon compounds. Measurements made with silicium chloride, bromide, and ethyl, quartz, tridymite, opal, and methyl, ethyl, and other silicates show that the atomic refractivity of silicium not only depends upon the type of the combination, but also upon the nature of the elements entering into combination with it. In compounds of the type SiX_4 the atomic refraction rises as the following constituents are substituted:—alcoholic radicles, chlorine, bromine, and alkyl. Similar rules apply to the dispersive power. In the two propyl silicates, an interesting result is obtained. The orthosilicate shows an atomic refraction of Si amounting to 7·58, whereas the disilicate gives a value 6·04. This is probably owing to the presence of the group Si — O — Si. E. E. F.

822. *Effect of Light on the Combination of Hydrogen and Bromine.* **J. H. Kastle** and **W. A. Beatty.** (Chem. News, 77. pp. 111–112, 1898.)—It is stated that H and Br do not combine at ordinary temperatures, even in sunlight. In these experiments sealed glass bulbs containing bromine vapour and an excess of purified but undried hydrogen were heated under different conditions of light in the vapour of orthotoluidine boiling at 196° C. At this temperature, strong sunlight in 15 minutes caused about 50 per cent. of combination; on further insolation, the reaction was nearly complete. Diffused daylight effected a slow change, while in the dark there was practically no result. S. G. R.

823. *Indicators.* **John Waddell.** (Journ. Phys. Chem. 2. pp. 171–184, 1898.)—According to the dissociation theory an indicator must be a weak base or a weak acid in which one of the ions has a different colour from that of the undissociated substance (Ostwald). The presence of a liquid in which the indicator dissociates less readily than in water should cause the colour due to

the ion to be diminished. The author explains his results as follows:—Salts become dissociated in alcohol, but less than in water, still less in acetene, and very slightly, if at all, in ether, benzene, and chloroform. When dissociated, the acid ion is visible in *alkaline* solution, the basic ion in *acid* solution. Solvents will discharge or restore the colour according as they cause, or "force back," dissociation. The action is not due to precipitation, and is more marked with acetic acid and ammonia than with HCl and potash, while concentration has also an influence. The annexed table is a summary of conclusions.

Substance.	Nature.	Undissociated.	Acid ion.	Basic ion.
Fluorescein.	Acid & base.	Colourless.	Green fluorescence.	Yellowish-green colour.
Phenacetolin.	Acid & base.	Pale pink.	Bright pink.	Yellow.
Phenolphthalein.	Acid.	Colourless.	Red.	——
Paranitrophenol.	Acid.	Pale yellow.	Yellowish-green.	——
Cyanine.	Base.	Blue.	——	Colourless.
Methyl orange.	Base.	Yellow.	——	Red.
Tumeric.	Acid.	Yellow.	Red.	——
Lacmoid.	Base.	Blue.	——	Red.
Coralline.	Acid & base.	Pale yellow.	Red.	Yellow.

Some of the changes given would make striking lecture experiments.

S. G. R.

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824. *Ionisation of Alkaline Silicates.* **L. Kahlenberg** and **A. T. Lincoln.** (Journ. Phys. Chem. 2. pp. 77–90, 1898.)—Following Kohlrausch's researches (Zeit. phys. Chem. 12. p. 773, 1893), the freezing-point and conductivity of solutions of silicates of Na, K, Li, Rb, and Cs were determined. The salts were obtained by adding to dialysed silica the required amount of standard solutions of the pure hydroxides. It was first proved that solutions of sodium silicate prepared from various specimens of colloid silica were identical with one another, and with the product from the crystals of Na_2SiO_3, $9H_2O$. The freezing-points were determined by Beckmann's apparatus,—using a thermometer reading by a lens to thousandths of a degree; the conductivities by Kohlrausch's method. Great precautions were taken to exclude CO_2. Owing to gelatinisation, the strongest solution of lithium silicate that could be prepared was one thirty-second, of other silicates $\frac{1}{8}$ of a gramme-molecule per litre.

With regard to lowering of freezing-point, Na_2SiO_3 showed a value, for progressive dilutions, approaching one-fourth the molecular weight, proving that the active ions were two sodium and two hydroxyl, with the silica almost inoperative, *and that the decomposition was practically complete at 48 litres per gramme-molecule.* Calculation from the soda alone confirmed the result,

being half its molecular weight. $NaHSiO_3$ gave a value of one half, equal to one of sodium and one of hydroxyl. $Na_2Si_5O_{11}$, selected because an analogous lithium silicate occurs in nature, gives a result which is similar, but the hydrolytic decomposition, as was to be expected from the law of mass, is not so far advanced at the same stage of dilution. K_2SiO_3 and $KHSiO_3$ were also in agreement, while lithium silicates were dissociated rather more easily, but followed the same law. Rubidium and cæsium showed signs of similar behaviour.

The conductivity was observed 5 or 6 hours after dilution, when the time and temperature factors observed by Kohlrausch had become constant. The determinations, compared with those specially made of the alkalies alone, confirm that author's opinion that the silicates in solution are hydrolytically decomposed into the hydroxide and colloidal silicic acid. Attention is drawn to the fact that in natural waters the recorded silica has never exceeded one gramme-molecule in 48 litres, and is generally very much less; consequently that the silica is always dissociated and in the colloidal state, which may account for various silicious deposits, some alterations of rocks, and certain absorptions by the roots of plants. The paper includes eleven tables of determinations.

S. G. R.

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825. *Equilibrium of Stereoisomers.* **W. D. Bancroft.** (Journ. Phys. Chem. 2. pp. 143–158 & 245–255, 1898.)—The theory of Duhem (Zeitschr. phys. Chem. 22. p. 545, 23. pp. 193 & 497, 1897) is applied to numerous chemical substances. The mutual changes of two physical modifications of the same substance, with the equilibria attained at various temperatures, and the accompanying change in the freezing-point, are explained by a graphical method in preference to Duhem's analytical treatment. Instances are then adduced from the literature of organic chemistry of the variation of melting-point with the past history of the sample, and it is shown how these become intelligible in the light of the theory of allotropic change with variable reaction velocity. In the second paper the case of the presence of a third physical species (as an indifferent solvent, etc.) is considered. B. B. T.

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826. *Equilibrium of Stereoisomers of Acetaldoxime.* **H. R. Carveth.** (Journ. Phys. Chem. 2. pp. 159–167, 1898.)—The peculiarities in behaviour of the freezing-point of acetaldoxime noticed by Dunstan and Dymond [J. Chem. Soc. 61. p. 471 (1892), 65. p. 206 (1894)] are studied more fully and explained by means of Duhem's theory and Bancroft's diagram (see Abstract 825, above). The equilibrium is independent of the temperature and unaffected by sunlight. The stable triple point is 13° C. From acetone the β-modification does not crystallise out even at $-80°$ C. The liquefaction of the crystals is not accompanied by a measurable change of vapour-pressure; and it is probable that two modifications exist in the vapour. B. B. T.

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827. *Solubility of Naphthalene in Aqueous Alcohol.* **H. P. Cady.** (Journ. Phys. Chem. 2. pp. 168–170, 1898.)—Aqueous acetone from 10 to 70 % is saturated with naphthalene, and the temperatures determined at which the solutions separate into two layers. Tables are given from 30° to 70° C. No unsaturated solution of naphthalene in aqueous alcohol could be found that formed two layers on heating. B. B. T.

828. *Electrolytic Deposition of Silver and its Separation from Copper.* **F. W. Küster** and **H. von Steinwehr.** (Zeitschr. Elektrochem. 4. pp. 451–455, 1898.)—Instructions for the electrolytic determination of silver are to be found in many text-books, but notwithstanding that such directions are carefully followed, the results obtained by the authors after many trials are always uncertain and usually unsatisfactory. The directions given err in insisting upon the maintenance of a certain current-density, instead of a constant E.M.F. In order that the metal may be precipitated in a weighable form, it is essential that the E.M.F. should not exceed a certain value; but as electrolysis proceeds, the concentration of the silver in the solution decreases and the resistance of the cell increases. If therefore the current is kept constant, the E.M.F. in the cell must increase, and may soon exceed the limiting value. Upwards of 100 experiments were made with a view to finding the most suitable experimental conditions. It was found that perfect precipitation is obtained when the solution (volume about 150 c.c.), containing about 0·5 gram of silver, is mixed with 1 or 2 c.c. of nitric acid, sp. gr. 1·4, and 5 c.c. of alcohol, the E.M.F. being kept constant at 1·35 to 1·38 volts for from 6 to 8 hours. Excellent results are obtained by this method of working, the maximum deviation from the mean of six analyses of an ordinary coin amounting only to 1 in 2000. J. W.

829. *Electrolytic Reduction of Aldehydes and Ketones.* **H. Kauffmann.** (Zeitschr. Elektrochem. 4. pp. 461–464, 1898.)—The use of alcoholic soda for the solution of the compound is recommended in place of the bisulphate, as described in a previous communication. The kathode consists of a strip of lead, the anode of platinum foil; dilute soda is used as the anode fluid. Benzaldehyde is reduced to the two stereoisomeric hydrobenzoïns, and other aldehydes and ketones behave in a similar manner. Similarly, from benzil are produced tetraphenylerythritol and other compounds, the constitution and identification of which are discussed at length. Reduction by electrolysis is thus leading to results essentially different from those obtained by chemical means. J. W.

830. *Electrolysis of Calcium Chloride Solutions.* **H. Bischoff** and **F. Foerster.** (Zeitschr. Elektrochem. 4. pp. 464–470, 1898.) —It was observed by Oettel that in the production of chlorates

by electrolysis, the behaviour of calcium chloride differed essentially from that of potassium chloride: in the former case, current-yields up to 87 % of chlorate can be obtained, whilst in the latter the yield seldom exceeded 60 %. The authors conclude from their experiments that the explanation lies in the sparing solubility of the lime, which, forming a thin film on the kathodal plate, to some extent protects it from immediate contact with the solution, and restricts the reducing action of the current. The greater part of this lime of course reacts with the free chlorine from the anode to form hypochlorite and chlorate; but a not inconsiderable amount falls from the kathode, and collects at the bottom of the vessel out of reach of the chlorine. It is to be observed that barium chloride resembles potassium chloride in its behaviour on electrolysis, baryta being much more soluble than lime. The most suitable conditions for the production of calcium chlorate are found to be a concentration of at least 10 % of calcium chloride, a current-density of 0·001 ampere /cm^2 at the anode, and at least double this at the kathode. J. W.

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831. *Gutta-Percha.* **E. Obach.** (Soc. Arts Journ. 46. pp. 97–114, 117–133, 1897; and pp. 137–164, 169–197, 1898. Also Electr. Eng.) [The first part of these Cantor lectures is given in Abstract No. 537, p. 277, 1898.]—Besides the original species, many other trees such as Payena, called *Sundék* or *Soondie*, yield commercial sorts of very unequal value. "Gutta" is derived from the Malayan *getah*, meaning a viscous juice, "pertja" is a mistake in the name of the plant, the proper one being "getah tabu." The tree is entirely confined to a rectangular area (a map of which is given), 6° on each side of the equator and from 99° to 119° E. lat. The attempts at cultivation to replace the ravages created by cutting-down have been singularly unfortunate. It is propagated from seeds or by "marcottage" or laying. The yield of an adult tree may reach 2½ lbs., valued at 8*s.* 9*d.* It is extensively adulterated by the natives.

Composition and Analysis.—Pure gutta (Payen) $(C_{10}H_{16})_n$, the most valuable ingredient, is soluble in carbon bisulphide or chloroform, insoluble in alcohol, ether, or cold petroleum spirit. The latter solvents extract two oxidised resins—*albane*, crystallisable in needles, soluble in hot, but not in cold alcohol; and *fluavile*, yellow, amorphous, and soluble in cold spirit, besides a somewhat indefinite substance called "guttane." The commercial value of a crude sample is not only judged by the proportion between the pure gutta and the resin, deducting the water and dirt, classed together as "waste," but by the physical characters of the "pure gutta" itself. Materials in which the percentage of resin ("*r*") reaches or even exceeds that of pure gutta ("*g*") are of inferior quality. The name of "Pahang" is now applied to the best qualities, irrespective of the source. "Re-boiling" is an operation performed by the Chinese, who buy up odd lots, soften in hot water, and mix to a second-rate material. A large number of

valuable commercial details, tables of analyses, valuations, figures of export and prices are given. Also a sketch of an apparatus for rapid proximate analysis.

Mechanical cleaning.—Brooman's apparatus (1845) washes and kneads the gutta between rollers in tanks of hot water. Hancock's (1847) slices, breaks, and minces under hot water, and then strains it by squeezing in the plastic state through fine wire-gauze. Masticating, mixing, and rolling machines follow, each of which are illustrated. The loss or "waste" during cleaning and drying sometimes reaches 50 %, the actual yield being usually 6 to 9 % less than that indicated by analysis. The percentage of "waste" is now about twice as great as it was 20 years ago. Foreign bodies of large size are often fraudulently introduced into the blocks of raw material, and sometimes cause serious injury to the machines. The author has succeeded in discovering these extraneous matters by the X-rays, to which gutta-percha is exceedingly transparent.

Chemical washing.—Caustic alkali and chloride of lime neutralize acidity, remove odour, and produce a lighter colour, but the process requires great care and thorough subsequent washing.

Chemical hardening, introduced by Obach 20 years ago, is the extraction of resin by petroleum spirit of 0·65 to 0·67 sp. gr. The material is chopped, dried, and percolated with spirit, which is re-distilled and used again; finally the purified gutta is masticated and kneaded with steam.

The mechanical properties of gutta should be greatly improved by hardening, while the electrical ones should be only slightly affected. But in practice the commoner sorts, which are usually selected for this treatment, contain also a gutta of inferior description, hence the product, though low in resin, is not equal to the superior kinds obtained directly from the tree. It possesses, however, much greater toughness at low temperatures, hence would be valuable for ice-boats: at present it is used in large quantities for golf-balls.

Chemical extraction.—Carbon bisulphide and other solvents easily separate the "waste," but the product obtained on evaporation quickly perishes, probably on account of molecular alteration. On the other hand, precipitation of the solution by alcohol separates the pure gutta from the resins, and is frequently practised.

Extraction from leaves and branches.—The reason for the destruction of the trees is that the juice does not flow so freely by tapping as when they are felled. But 6 years ago it was proposed to utilise the branches, twigs, and leaves, which can be removed at intervals without injury to the plant. In this way adulterations would be prevented, as the leaves are easily distinguished by the veins, etc. When a leaf or stem of *Palaquium gutta* is torn asunder, a web of fine white threads will be seen stretching across the gap: these are coagulated latex, and in inferior species they are not so numerous or tenacious. A tree 10 years old yields about 15 lbs. of dry leaves; at 30 years it yields 25 lbs.; therefore

if regularly plucked, the total product would be 420 lbs. containing 9 to 10 % of gutta, or 40 lbs. nett, *i.e.* at least 20 times as much as if felled and bled in the customary way. On the other hand, the bulk of the leaves is about 15 times that of the raw gum as exported.

Three patented processes for the extraction are described and figured. Rigole in 1892 employed CS_2 and steam, afterwards evaporating; while in the same year Sérullas introduced hot toluene, precipitating the gutta by means of acetone, in this way obtaining a pure and preferable article. Ramsay has recently suggested *resin oil* instead of toluene. A company has lately been floated for working the Sérullas process. Lastly Obach makes use of a single liquid, boiling petroleum ether, crushing the leaves between rollers: on cooling the solution below 60° F. the pure gutta is completely precipitated. No satisfactory *mechanical* process has hitherto been devised.

Natural substitutes.—Obach and others have examined a large number of "pseudo-guttas," but the only one of real value is *Balata*, the latex of the "bullet tree," a *Sapota* or *Mimusops* from Jamaica, Trinidad, Venezuela, the Guianas, and other regions. The trunk is tapped, as the latex is more liquid than that of gutta-percha. A gallon of milk yields by evaporation 4 lbs. of pinkish or greyish balata, fetching 10*d.* or 11*d.* per lb. Original analyses are given, from which it appears that the sp. gr. is about 1·006, that the gutta is strong and tough and probably identical with that from the *Palaquium*, but that the amount of resin is so large "that the material can only be regarded as a substitute for second, or perhaps even third class gutta-percha." The average price in London is 1*s.* 10*d.* per lb.

Artificial substitutes are numerous. Mourlot in 1878 prepared an insulating material, "Gutta française," from birch-bark by distillation, at 2·5 francs per kilo. It was said to render gutta more durable and to protect it against the attacks of rats, but the lecturer's opinion of it was not favourable. "Velvril" is a compound of collodion cotton and nitrated castor or linseed oil. It is moulded in manufacture, but when once hardened cannot be softened by heat alone. "Chatterton's compound," a mixture of gutta, colophony, and Stockholm tar, is largely used as a binding material in cables.

Numerous diagrams and statistics, and elaborate tables of compositions and physical properties, with descriptions of applications and of the behaviour towards oxygen and ozone, conclude a most valuable monograph on the subject. S. G. R.

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832. *Electrolytic Alkali by the Hargreaves-Bird Process.* **J. B. C. Kershaw.** (Electrician, 40. pp. 547–549, 1898.)—This article contains a description of the experimental electrolytic plant at Farnworth, with details of the observations and tests made on the occasion of two personal visits of inspection, in November and January last.

The motive power is supplied by a 20 H.P. gas-engine, and the whole of the electrical energy developed is utilised in one large electrolytic cell, constructed according to the Hargreaves-Bird arrangement. The two side walls of this cell form the combined kathode-diaphragms, and each has a superficial area of 50 sq. feet. The kathode area of the cell is therefore 100 sq. feet.

A peculiar form of compound anode, the invention of Mr. Connor of Belfast, is used in the inner anode chamber of the cell. The brine in this chamber is kept at a high temperature by the heating effects of the current, and of the steam in the outer kathode chambers. On the occasion of the writer's visits the temperature was 70° C. The normal current with which this cell is worked is 2200 amperes, and 224 lbs. of dry salt are decomposed in it per 24 hrs. Details of two runs are given in the article. The current efficiencies were 92·7 % and 90·4 %, while the energy efficiencies were 50 % and 48·9 %. These percentages have been worked out upon the same basis as that used in an earlier article by the writer upon electrolytic soda and bleach. Two illustrations help to elucidate the text. AUTHOR.

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833. *Bullion Refining.* **J. B. C. Kershaw.** (Electrician, 41. pp. 187–189, 1898.)—In this article the writer deals with the refining of gold bullion, with especial reference to the parting of gold from platinum. In the historical notes upon the subject, he describes the chemical method introduced by D'Arcet into Paris in 1802, and by Matheson into London in 1829. The modification of this original method known as the "Gutzkow process," and used down to the present date, is then described. A detailed account of the electrolytic method worked out by Dr. Wohlwill and his assistants at the Nord-deutsche Refinery, Hamburg, in the period 1878–95 follows. This process depends upon the use of the impure gold bullion as anode in a hot solution of auric chloride containing excess of hydrochloric acid, or of the alkali metal chlorides. The kathodes are formed of thin sheets of pure gold, hung at a distance of 3 cms. from the anodes. The current-density used varies from 95 up to 190 amperes per sq. foot, and at the lower density an E.M.F. of 1 volt is found sufficient to drive the current through each vat of the series. The silver is found as insoluble silver chloride in the anode slime, with some gold. The platinum and palladium pass into solution, and are recovered at long intervals by chemical means. If the bullion contain only 1 part of platinum per 1000, with a daily treatment of 20 kilos, 2 kgs. platinum will be collected in the electrolyte in the course of 100 days. This process has been in operation for some time at the works of the "Frankfürter Gold und Silber Scheide Anstalt" at Hamburg, where a plant covering only 64 sq. feet of ground-space suffices to produce 75 kgs. fine gold per 24 hours.

A considerable portion of the article is devoted to the chemistry of the process, and to Dr. Wohlwill's explanations of the changes occurring in the electrolyte. The latter has discovered that gold

will not dissolve unless the conditions favour the formation of salts of the type AuClMCl, or $AuCl_3MCl$; and it is the non-recognition of this fact that has hindered the development of an electrolytic process for refining gold. Space is also given to Dr. Wohlwill's theory regarding the origin of the gold found in the anode slimes.

The article concludes with a prophecy of the writer that the electrolytic method of gold refining will ultimately displace the older chemical methods, by reason of its greater economy, simplicity, and cleanliness. AUTHOR.

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834. *Electrolysed Sea-water for Disinfecting.* **W. L. Hedenberg.** (Elect. Engin. 21. pp. 681–682, 1898; also 'Electricity,' N. York, 14. p. 296, 1898.)—The author in this short article discusses the Woolf and the Hermite systems of sewage disinfection. After some general remarks upon the problem, he gives an account of the former as used experimentally at Brewsters, at Riker's Island, and at Danbury. The process was first tried at Brewsters, New York, in 1893, with a plant comprising a 15 H.P. engine and a dynamo yielding 700 amperes at 5 volts. The most striking effect gained here was the diminution of Bacteria in the sewage-contaminated water; the number being reduced from 22,000 to 42 per cub. centimetre. The system was operated at Riker's Island, the dumping-ground for New York's garbage, in 1894. A plant capable of producing 4000 gallons of the disinfecting fluid per hour was mounted upon a barge, and the fluid was sprayed upon the heap at various points by means of a pump and lines of hose-pipe. The results, from a sanitary point of view, were successful.

At Danbury, Conn., the system was used to disinfect the sewage of the town before discharge into a neighbouring river. The plant comprised a 40 H.P. engine and a dynamo yielding 1000 amperes at 5 volts. The disinfecting fluid produced was mixed with the sewage, in a special mixing-tank provided with agitators, before the sewage was discharged into the river. The results were not satisfactory, since the solid matters of the sewage remained unacted upon, and later occasioned trouble; and the system has been abandoned at this place. Two illustrations are given, of Woolf plants in U.S.A.

The remainder of the article deals with the experimental trials of the Hermite system in England, France, and India, and contains little information not to be found in the earlier article on the Hermite process by Kershaw in the same paper (see Abstract, No. 842, 1898). J. B. C. K.

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835. *Electrolytic Treatment of Tin Residues.* (Ind. Électrochim. 2. pp. 2–3, 1898.)—In the manufacture of vessels of tinned iron there is a loss through waste of 6–7 %, which, together with old rejected vessels, amounts to thousands of tons annually. The difficulties in the treatment of these residues arise from their large

bulk, and from the presence, under the layer of tin, of an alloy of tin and iron. In some works caustic soda solution is used as an electrolyte, which dissolves the tin, but not the alloy of tin and iron. The iron left has therefore but little commercial value, owing to the relatively large proportion of tin still retained by it. In another recent process the scraps of metal are packed in wood frames and serve as the anode, while the tin is deposited upon kathodes of tinned copper. Dilute sulphuric acid is used as the electrolyte, and the iron is eventually completely dissolved and converted into the crystalline sulphate. J. W.

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836. *Electrolytic Treatment of Nickel Ores.* (Ind. Électrochim. 2. pp. 12–13, 1898.)—The crude *matt* obtained by the Canadian Copper Company contains approximately equal parts of nickel, copper, iron, and sulphur, besides traces of gold, silver, and platinum. It is repeatedly fused with coke and sodium sulphate, whereby a fairly pure nickel sulphide and a copper slag are produced. The latter are lixiviated to remove sodium salts, reduced in a reverberatory furnace, and the copper cast into anodes and refined in a bath of the sulphate. The mud collecting in the bath is worked up for the precious matal. The nickel sulphide, on the other hand, is roasted with salt and lixiviated. Copper, gold, and silver pass into solution as chlorides and sulphates, and are afterwards precipitated. The nickel oxide remaining undissolved is reduced in a reverberatory furnace, and cast into anodes containing 95–96 $^0/_0$ of nickel. These are taken by the Balbach Smelting and Refining Company of Newark, and refined by the ordinary electrolytic process. The metal produced contains 99·5–99·7 $^0/_0$ of nickel, with traces of copper, arsenic, sulphur, iron, and platinum. J. W.

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837. *Electrolytic Treatment of Complex Ores of Zinc, Lead, and Copper.* (Ind. Électrochim. 2. p. 13, 1898.)—According to the process of E. C. Ketchum of Boston, the ore, after a preliminary roasting, is treated with a hot 25 $^0/_0$ solution of caustic soda. Zinc and lead are dissolved; iron, silver, and copper being unattacked. The solution is run into a series of electrolytic bath tanks, and the lead precipitated upon iron kathodes by a current at 1·8 volts. The zinc remains in solution, and is precipitated upon zinc sheets, in a second series of tanks, by a current at 2·1 volts. The drawbacks to the process are the high price of the soda solution and its rapid carbonation on exposure. J. W.

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838. *Hypochlorite of Soda by the Tailfer Electrolytic Cell.* (Ind. Électrochim. 2. pp. 18–19, 1898.)—In this apparatus the sodium hydrate and the chlorine produced by the electrolysis of a solution of common salt are allowed to react in a separate vessel provided with an agitator, called the "Absorber." The electrolytic cell itself is provided with anodes of gas-carbon and kathodes of iron, sepa-

rated by asbestos diaphragms. The anode compartment is closed above, and its side walls are formed by these diaphragms. The strength of the hypochlorite solution obtained depends upon the concentration of the sodium hydrate solution run into the "absorber," but it is not always profitable to attempt to utilise more than 50 % of the sodium chloride. A calculation is necessary in order to ascertain the most favourable conditions of work for each individual case.

M. Tailfer gives details of the first cost of a 20 H.P. installation, and of the costs of running the same. If water-power be available, he estimates that a saving of between 40 and 50 francs a day is effected by the use of the electrolytic method for production of sodium hypochlorite; while if steam-power be used, the saving is reduced to 25 francs daily. With larger installations the saving is more striking, since the working costs remain practically stationary. J. B. C. K.

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839. *Electro-Deposition of Iron.* (Ind. Électrochim. 7. pp. 20–21, 1898.)—The electrolysis of iron salts has hitherto been made use of for the preparation of iron in the state of powder, for the strengthening of stereotype plates, and for the steel-facing (*acierage*) of small articles. According to the conditions, the metal may easily be obtained either in a pulverulent form, or as dense and hard as tempered steel. The dense product contains a large amount of occluded hydrogen, sometimes as much as 200 times its volume. For the production of the powder the use of citrate or oxalate of iron is to be preferred; but the regulation of the current-density is the most essential point to be observed. For the production of dense coherent deposits, sulphate of iron is almost always used. The metal deposited from solutions of the chloride has a tendency to oxidise rapidly, and the presence of chlorides should therefore be avoided. The solution of the sulphate should be neutral, and, according to the majority of the various modes of procedure, is mixed with a certain proportion of sulphate of ammonium, sulphate of sodium, or sulphate of magnesium. Sometimes the iron deposited is afterwards oxidised and a fine bluish-black layer of magnetic oxide obtained, nearly as hard as iron. In all cases anodes of iron are employed of the same dimensions as the kathodes; the current-density varies from 0·15 to 0·45 ampere per sq. dcm., and the E.M.F. required is 1 to 1·3 volt. J. W.

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840. *Electroplating Plants.* **C. F. Burgess.** (West. Electn. 22. pp. 195–197, 1898.)—This article gives a careful review of the various conditions which have to be fulfilled in order to obtain economical working. C. K. F.

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841. *Sterilisation of Water by Ozone.* **E. Andréoli.** (Électricien, 15. pp. 226–229, 1898.)—A critical notice of the report of Professors van Ermengen and Gérard upon the exhibit of the

Tindal ozoniser and sterilising apparatus at the 1897 Brussels Exhibition. The exhibit comprised a Mordey dynamo, a Schneller transformer, and a Tindal ozoniser and steriliser. The dynamo yielded a current of 30 amperes at 80 volts, which was raised in the transformer to a very high voltage. In the ozoniser, air specially dried was submitted to the silent discharge of the high-tension current; and the ozonised air was then used in the steriliser for purification of Brussels water.

The author in the first place criticises the method used by the Professors for determination of the ozone. It is one designed for the estimation of ozone in oxygen, and its author, Dr. Houzeau, has stated that it is inapplicable when nitrous compounds may be present. As regards the output of ozone per k.w., the figures published by the Professors show that 2400 litres dry air passed through the ozoniser per hour, and that the amount of ozone present at the exit varied from 3·0 to 4·3 grams per cub. metre of air. The consumption of electrical energy per gram of ozone produced, worked out to between 244 and 252 watts. The electrical energy per cub. metre of water sterilised varied from 75 to 95 watts. If this energy be supplied at a cost of 10 centimes per k.w., the cost of treatment will lie between ·80 and 1·0 centime per cubic metre (35·3 cubic feet) of water. The Professors close their report with the statement that the Tindal ozoniser appears to convert the whole of the electrical energy into ozone. The author strongly dissents from this statement, and asserts that the theoretical yield of ozone is 1030 grams per H.P. hour, while many ozonisers yield 10–20 times as much ozone per H.P. hour as the Tindal ozoniser. The low efficiency of the latter form of ozoniser is attributed by the author to the absence of a dielectric plate between the opposing electrodes, and to the use of a glycerine-and-alcohol resistance-cell in the circuit. The former causes indirect loss by heating of the air and decomposition of the ozone already formed; the latter occasions a direct loss by reduction of the voltage of the current used. In the author's opinion, the results of the tests with this apparatus at Brussels are encouraging to owners of ozonisers which have from 10 to 20 times the efficiency of the Tindal ozoniser, since they show how little ozone is sufficient to sterilise an ordinary drinking-water.

The Tindal apparatus is to be installed shortly on a large scale at Paris. J. B. C. K.

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842. *Electro-Chemical Industries of Europe.* **J. B. C. Kershaw.** (Electricity, N. York, 14. pp. 116, 147–149, 196, 244, 280–281, 311–312, 1898.)—In articles 15–20 of the series which have been appearing in this paper since August of last year, the writer deals with the Hargreaves-Bird Process, Organic Products, the Hermite Processes, Magnesium, Chromium and Nickel, Bullion Refining, and Electrolytic Tin.

The facts and figures contained in Art. 15, upon the Hargreaves-Bird Alkali Process, have already received notice (see Science

Abstracts, No. 832).—In Art. 16, the applications of Electrolysis as an aid in the manufacture of organic chemicals and dyes are dealt with. According to the writer, Iodoform and Chloral are produced by electrolytic processes by the firm Vorm. E. Schering, of Berlin; Yellows and Congo-reds, at Ludwigshafen, by the Badische Anilin u. Soda Fabrik; and Aniline dyes by Fried. Bayer u. Cie at Elberfeld. Upon the authority of Oettel it is also stated that "nearly every German colour-works is provided with an electric installation, and the necessary accessories for electrolytic work." The production of Cyanides and Ferro-cyanides by Readman's process, which is shortly to be worked in Scotland, is also briefly noticed.—Article 17 deals with the Hermite bleaching and disinfecting processes. The plant at Stjernfors, Sweden, for bleaching wood-pulp, and the disinfecting plant erected at Ipswich, England, are described in detail. The writer considers that electrolytic bleaching processes have a future; but he is somewhat sceptical regarding the success of the processes for disinfecting sewage.

The electrolytic production of Antimony, Chromium, Magnesium, and Nickel is the subject of Art. 18. Electrolytic antimony has been put upon the metal market in Europe, and a description of the Siemens and Halske process, which the writer believes has been used in its production, is given. Chromium is produced at the Elektro-chemische Werke, Bitterfeld, probably by an electric-furnace method similar in principle to that used by Moissan. Magnesium is produced at Hemelingen, at Trotha, and at Bitterfeld by electrolytic methods; and a detailed account of the process used at the former place is given. Electrolytic nickel is produced by two Firms in U.S.A. and one in Germany. The principle of the method used in all three cases is the same. A copper-nickel matt is cast into anodes, and is used in a bath of copper and nickel sulphates. When the electrolyte is acid, copper alone is deposited; when neutral, the nickel also separates at the kathode. The writer states his opinion that, as regards chromium, magnesium, and nickel, the electrical processes will have a successful future.—Article 19 relates to Bullion Refining. The Mœbius Silver-refining process is in operation at Frankfort in Germany, and at St. Louis and at Perth in U.S.A. The Wohlwill Gold-parting process is in operation at Hamburg. A detailed description of the plant at Frankfort is given, together with some details of the Wohlwill process as operated at Hamburg. Brief mention is made of the Rossler-Edelmann process for recovering the silver from argentiferous lead. The writer considers that, as regards the precious metals platinum, silver, and gold, the electrolytic parting methods will entirely displace the older chemical methods.—In Art. 20 the Recovery of Tin from tin-scrap, and the Refining of Commercial Tin are dealt with. As regards the first, the processes of Siemens and Halske, of Smith, and of Claus receive notice. The two former are stated to be at work in Germany; while use of the latter, on the authority of Claus, is about to be made in England. The electrolytic refining of tin, as carried out at Messrs. Bolton's works in Staffordshire, is

described. The writer calculates that 193·8 E.H.P. days of 24 hrs. would be requisite to produce 1 metric ton of pure tin by any of these processes; and taking the cost of the E.H.P. hour at \$·002 ($=\frac{1}{10}d.$, *i. e.* the cost of electrical energy at Niagara), he estimates the cost of electrical energy per ton of tin at \$9·30 (=38*s.* 9*d.*). He therefore considers that the electrolytic recovery of tin from tin-scrap would prove a profitable industry, if the scrap could be collected at a reasonable cost. AUTHOR.

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843. *Electric Furnaces.* **G. Richard.** (Écl. Électr. 13. pp. 481–486, 1897.)—This is an illustrated and detailed description of the chief electric furnaces at present in use. Amongst those described are the furnaces due to Patten, Eldridge, Wright and Clark, Denther, Bullier, Price, and Combes. W. G. R.

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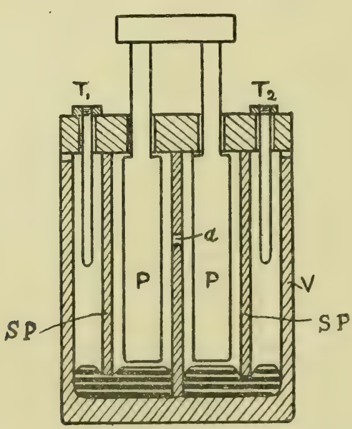
844. *Accumulator Plates.* **H. Weyer.** (Elektrochem. Zeitschr. 4. pp. 198-208, 1897.)—A *résumé*, unsuited for abstraction, of improvements recently made in the construction of the essential parts of accumulator electrodes. References are given to upwards of a hundred patents. J. W.

845. *Mouterde Accumulator.* (Elektrochem. Zeitschr. 5. pp. 10-13, 1898.)—The electrodes are cylindrical. The outer one, which also serves as the containing vessel, is a cylinder of lead strongly ribbed on its inner surface with horizontal ridges. It forms the positive electrode, the active material being contained in the furrows between the ridges. The negative electrode consists of a smaller cylinder with ridges on its outer surface; these ridges are made of somewhat greater depth than those on the positive electrode. A thin envelope of perforated lead surrounds the negative electrode, and prevents the active material from dropping out. The rates of charge and discharge are said to be exceptionally high. It is also claimed by the inventor that a series of short-circuits increases the capacity of the cell, and this view appears to be borne out by the results of some experiments which are quoted. A. H.

846. *Mercury Switches.* **P. Janet.** (Ind. Élect. 7. pp. 96-98, 1898.)—The author describes a form of mercury switch, the essential parts of which will be understood by reference to the sketch given below. V is a vessel of insulating material divided into



two compartments by an insulating partition which is perforated at *a*. Two subsidiary partitions SP extend from the top of the vessel to within a short distance of the bottom. T_1 and T_2

are the terminals. The vessel contains mercury, and by lowering the plungers PP the mercury is forced up, making contact first with T_1 and T_2 and then completing the circuit through *a*. It is evident that the *break* takes place between the two mercury columns at *a*. For high-pressure circuits the vessel is divided into a larger number of compartments, so as to have several mercury breaks in series. The author states that such switches have been tried on 3000-volt circuits. A. H.

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847. *Commercial Tests of Accumulators.* **E. Hospitalier.** (Ind. Élect. 7. p. 129, 1898.)—In testing storage-cells for capacity and efficiency, there are three different methods of procedure, each giving different results. First, the cells may be discharged through a constant resistance. Second, the current may be kept constant: and, third, the power taken from the cells may be kept constant. Of these methods the first is the simplest and leads to the best results. The discharge should in all cases be continued till the E.M.F. (on open circuit) of the cell falls to 1·8 volts. The author thinks that there should be uniformity of method in commercial testing of storage-cells so as to render a comparison of their respective merits possible. W. G. R.

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848. *A new Fuse.* (Lightning, 13. p. 358, 1898.)—This new fuse, which is due to F. J. Borland, contains two fuse wires: one of these is much thinner than the other. In the normal state all the current passes through the thin wire, but on this fusing a bar which it supports falls and makes contact in a mercury cup, thus cutting in the thicker wire which will not fuse unless something is radically wrong. W. G. R.

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849. *A Lightning Arrester.* **R. B. R.** (Ind. Élect. 7. pp. 158–160, 1898.)—The object of the apparatus here described is :—

1. To conduct to earth in a definite way all atmospheric discharge taking place on high-tension lines.
2. To prevent a prolonged short-circuit between the line and earth.
3. To automatically reset itself after discharge.

The lightning arrester made by the Société d'Électricité Alioth fulfils each of these conditions, and is constructed as follows :—Fixed on a cast-iron frame are three porcelain slabs placed one above the other. The uppermost slab carries a brass terminal which is connected with the line to be protected. This terminal carries a carbon disc, opposite to which is another carbon disc attached to the end of an aluminium lever capable of rotation round a fixed point, and worked by means of an electromagnet. The lower end of the lever is connected to earth, and the distance between the carbon discs is such as to render impossible a discharge under the line-voltage only. W. G. R.

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850. *Automatic Alarm for Hotels.* (Elekt. Runds. 15. pp. 119–120, 1898.)—An illustrated description of an invention by which bells may be sounded at different times, as desired, in different rooms of a hotel by a revolving contact-drum which closes each circuit at the required time. A. H.

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851. *Electrical Low-water Alarm.* **Brown.** (Elect. Engin. 21. pp. 468–469, 1898.)—A mercury tube is encased, above normal water-level, in a metal fitting attached to the boiler front by a pipe with internal elbow, having its mouth at low-water level. Water or steam surrounds the mercury tube according as the water-level is above or below the elbow-mouth. As the mercury expands with the higher temperature of the surrounding steam, it makes contact with the ends of two platinum wires, so closing the circuit of an electric bell. A. S.

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852. *Station Photometry.* **B. Speed.** (Elect. World, 31. pp. 440–441, 1898.)—This article has been written to supply electrical engineers engaged in Station work with explicit and detailed directions for the construction and operation of a photometer department. The screen recommended is a Bunsen grease-spot. The standard of illumination is an incandescent lamp standardised by reference to carefully chosen standard candles, directions as to the choice and manipulation of the candles being given. Before using any lamps from a fresh consignment, one or two should be taken from the lot at random, and completely tested to see whether they fulfil the contract for life and candle-power. If these fail to fulfil the conditions two or three more should be tested, and if these fail the lot should be returned to the maker. W. G. R.

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853. *Electric Drilling Machines.* (Electrician, 40. pp. 849–850, 1898.)—The drill here described, and made by the Thames Ironworks, is driven by a shunt-wound overtype bipolar motor, the drilling machine being coupled to the motor and driven by a bevel-wheel and pinion. The machine stands on two stout limbs of an electromagnet which serves to grip the work and resist the thrust due to the feed of the drill. The ratio of reduction of speed can be altered by changing the set of gear-wheels at the motor. These machines have become indispensable for use in positions where the work would otherwise have to be done by hand. W. G. R.

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854. *Three-Phase Machinery.* **W. M. Venable.** (West. Electn. 22. pp. 208–209, 1898.)—The chief feature of this article is the novel way in which the author explains why three wires only are necessary in a three-phase installation. Considering first three separate and independent alternators, six wires would be

necessary. If the three machines are connected together at one terminal only, the effect would only be to bring those terminals to a common potential without altering the potential difference between any pair of terminals; hence two wires can be dispensed with and a common return used. But in a three-phase the sum of the three currents is always zero, so that this common return may be cut out and three wires only remain. W. G. R.

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855. *Submarine Torpedo Boat 'Holland.'* (Elect. Rev. N. Y. 32. pp. 211–212, 1898.)—This boat, which is 56 feet long, is propelled by a single screw driven by a direct-current motor having a normal capacity of 50 horse-power. Current for the operation is derived from 60 special-type chloride accumulators having an aggregate weight 45,000 pounds. These cells are capable of discharging 300 amperes for six hours. On spurts of speed lasting for about half an hour, the discharge rate may be increased to 1000 amperes. The battery-cells are constructed of steel, lined both inside and outside with lead. The ventilating of the boat when submerged is done by means of a one-half horse motor which drives out the foul air, fresh air being obtained from reservoirs. W. G. R.

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856. *Balancing of Engines.* **J. Whitcher.** (Elect. Engin. 21. pp. 459–462 & 488–492, 1898.)—The author discusses the subject in non-mathematical language, with special reference to inertia pressures on the bearings, and speed-limiting conditions. He divides bearings into three classes, in which the direction of the pressure is constant, alternating in direction, and rotating or oscillating over an arc of a circle. The principle of rotary-bearing pressure seems to afford a feasible method of passing the speed limits possible with constant or alternating pressures. The perfect balancing of the connecting-rod engine is a matter of great difficulty, and in practice approximations only are obtained. The author has invented two methods of balancing. In one the connecting rod is extended beyond the crank-pin a distance equal to its length between crosshead and crank, a weight equal to that of piston and crosshead is attached there, and a counter-weight is attached to the shaft opposite the crank-pin. In the other method, two links of length equal to the connecting rod swing about fixed axes, the plane of their motion being the same as that of the connecting rod. The paper is illustrated by eight figures. A. S.

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857. *Automatic Electromagnetic Block-Signal.* **W. Boult.** (Zeitschr. Elektrotechn. Wien, 16 pp. 65–68, 1898.)—The signalling is effected, not by discs or arms on the line, but by two small

aluminium arms in glass cases on the driver's platform of the engine. The difficulty of getting a reliable electrical connection between the signal-box and the driver's platform of the moving train is avoided. On the locomotive two groups of cells operate the signals; these are brought into action by means of a U-shaped bar of soft iron, which is magnetised on passing a magnetic field on the permanent way. A diagram illustrating the mode of operating is given. A. S.

DYNAMOS, MOTORS, AND TRANSFORMERS.

858. *Prevention of Commutator Sparking.* **J. Fischer-Hinnen.** (Ind. Élect. 7. pp. 70–73, 1898.)—The paper contains a brief account, with criticisms, of the various devices used for the prevention of sparking—such as Ryan's, Swinburne's, the author's, Sayers', Mordey's, and Brown's. The author suggests a special form of winding for a four-pole armature intended for use with laminated field-magnets in an alternate-current motor. A. H.

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859. *Armature Windings.* (Zeitschr. Elektrotechn. Wien, 16. pp. 17–23, 1898.)—This is an elaborate yet lucid paper on the theory of the windings of closed-coil continuous-current armatures. The writers establish the conditions (a) that the winding shall be simple (*i. e.* consisting of a single closed circuit), and (b) that each conductor shall be used once only in stepping round the armature. They then establish the general formula

$$\frac{y}{b}=\frac{1}{p}\left(\frac{\epsilon C}{b}\pm a\right),$$

where

y=number of conductors by which the first conductor of an "element" of the winding is in advance of the corresponding conductor of the preceding element,
b=number of conductors in an element of the winding,
p=number of pairs of poles,
C=number of conductors,
a=number of pairs of brushes,
ϵ=any integer which renders y integral.

The above formula is somewhat more general than that given by Arnold. Its use is exemplified by the consideration of a number of special cases. A. H.

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860. *Multipolar Armature Windings.* **A. L. Rice.** (Amer. Electn. 10. pp. 149–152, 1898.)—This is a continuation of the article abstracted in Abstract No. 442. The author gives descriptions and diagrams of a four-pole lap winding in two layers, a six-pole wave winding in two layers, and a four-pole two circuit gramme winding. In this last case the armature is connected up in series by connecting each coil to a commutator bar nearly at right angles to the coil, and carrying on a connection from this commutator bar to another coil nearly opposite the first one.
R. B. R.

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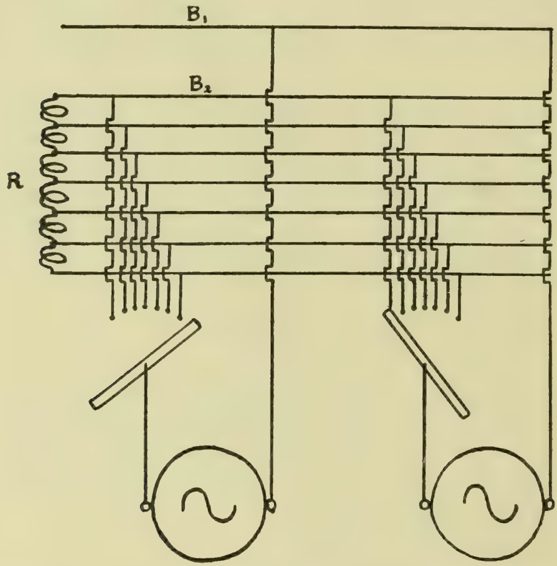
861. *Paralleling of Alternators.* **J. Sahulka.** (Zeitschr. Elektrotechn. Wien, 16. pp. 114–115, 1898.)—The author describes the method commonly used by Ganz & Co., in which the alternator

to be thrown into circuit is first run up to the proper E.M.F. on an artificial load at the central station, then brought into phase with the other machines and connected to the bus-bars—the artificial load being afterwards gradually removed. A serious objection to this method is that it involves a temporary increase in the total load whenever a new machine is coming into circuit. The author has devised the method illustrated in the accompanying diagram, in which B_1 and B_2 stand for the bus-bars, and R denotes

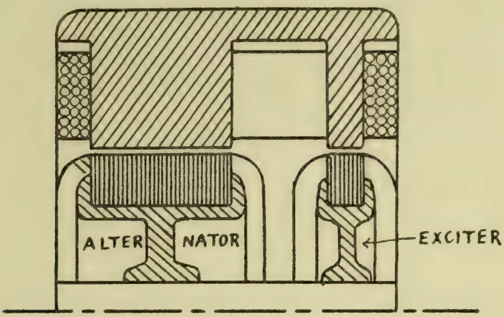


a reactance coil with subdivided winding connected to a multiple-contact starting switch. In starting a new alternator, the corresponding switch is moved over the successive contacts, the exciting current being at the same time adjusted so as to give the proper potential difference across the terminals. By this means the alternator is pulled into synchronism as soon as the switch closes its circuit, without appreciably disturbing the other machines.

A. H.

862. *Self-regulating Alternator*. (Elekt. Runds. 15. pp. 96–97, 1898.)—The following extremely ingenious method, due to E. Danielson, of Stockholm, enables the compounding of an alternator to be carried out without any necessity of rectifying the current. The exciter armature is mounted on the alternator shaft, as shown in the accompanying sketch. The same field-winding does for both alternator and exciter (the latter being series-wound). The regulation is effected by a supplementary winding *on the armature* of the exciter, which is supplied with an *alternating* current (either the main current of the machine or a

transformed current). This winding is so arranged with respect to the ordinary winding that the current in the latter is opposed to that in the former; and it is so proportioned that when the



alternating current is in phase with the E.M.F., the exciter armature reaction strengthens the field sufficiently to make up for the drop due to resistance and inductance in the alternator armature. If now the alternating current should lag behind the E.M.F., the armature reaction in the exciter will be increased so as to strengthen its field, and hence also the exciting current and field of the alternator, so that the P.D. across the terminals of the latter will remain unaltered. The method therefore possesses the advantage that it is capable of compensating automatically not only for the ordinary drop due to resistance and inductance, but for armature reaction brought about by phase shifting as well. It is equally applicable to single-phasers and polyphasers. A. H.

863. *Crocker - Wheeler Slow-speed Motors.* **G. S. Dunn.** (Elect. Engin. N. Y. 25. pp. 400–402, 1898.)—The 2 H.P. slow-speed motor runs at 100 revs. and has 8 poles and 8 brushes. The brush-spindles are connected to two rings, the positive brushes to one and the negative to the other. These rings are rigidly connected but insulated from one another. The rings are placed next to the armature, leaving the commutator clear and easy of access. The author points out a characteristic of slow-speed motors which in certain cases gives them an important advantage over others. Their moment of inertia is low and permits starting from rest in a minimum of time with a minimum of current. In the case of the 2 H.P. 100 revs. armature, the product of the moment of inertia by half the square of the angular velocity is 280 foot-lbs., while in the case of the 2 H.P. 1000 revs. motor it is 900 foot-lbs. Where the duty the motors have to perform requires quick and frequent starting and stopping, this difference is very noticeable and plays an important part in the economy of the plant. The regulation, however, is much less perfect with slow-speed motors. A 5 H.P. motor at 950 revs. will slow down 4 % when full load

is put on; but a 4 H.P. motor at 200 revs. will slow down 15 % under the same conditions. In shunt motors the field is controlled by a rheostat, or is wound in multiple sections, whose circuits are opened successively. Series motors have their speed controlled by short-circuiting various portions of the field. Compound motors have a constantly excited shunt, and a series field in two sections, or they have an unvaried series-coil with a shunt-coil whose strength is changed by a field regulator. All these motors are designed to be capable of an increase of 50 % above normal, and a decrease of 10 % below normal speed. Two kinds of controllers are used: the cylinder reverses giving as many speeds backwards as forwards. operating through a resistance, regulating the speed by cutting down the voltage supplied by the line; and a commuter, specially designed for use with a compound motor. The commuter varies the speed by changing the connections of the various field-coils. Three diagrams of cylinder reverses are given, for shunt, series, and compound motors, and one of a commuter. R. B. R.

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864. *Fan Motors.* (Elect. World, 31. pp. 407–411, 1898.)—This article describes the various types of electrically-driven ventilating fan on the market. Amongst the direct-current motors described is the Lundell motor with a single field-coil arranged obliquely around the two pole-pieces and the armature, the outer shell or casing forming the magnetic yoke; the Western Electric motor; and the Paragon motor. The Seller's type of bearing is usually employed with special lubricating devices. Of the low-speed motors, the Western Electric is described. In the self-starting single-phase alternating-current motor of the General Electric Co. (U.S.A.), the winding of the rotor or armature consists of bare copper rods run through slots in a laminated core and riveted into copper rings at either end. The rotary action of the field necessary for starting the motor is obtained by the use of "shading coils," *i. e.* short-circuited copper loops surrounding a part of a pole on which is placed the active primary winding. The currents set up in these loops lag behind the currents in the active winding, and hence set up a magnetisation in the sections of the poles on which they are wound out of phase with that in the other sections and give a rotating field. These short-circuited sections, however, constantly waste energy while the motor is running. In the Emerson motor, the arrangements for producing the phase-displacement can be cut out when the motor is brought up to speed. In the Tuerk motor for driving low-speed fans, the rotor runs at a fairly high speed and is provided with a pinion which drives the fan-shaft through leather-faced friction wheels shaped as frustra of cones and mounted on hinged inclined shafts; these wheels bear against the inside of an outer shell carrying the fan-blades, the proper pressure between the parts being maintained by hanging the shell and fans on these friction-wheels. The Wagner, Standard, and Diehl motors are also described, and also a

synchronous motor due to Mr. R. Lundell which prevents the occurrence of lagging or idle currents in the supply system. This motor has an external primary built up of laminated iron with 8 internally-projecting poles each wound with a coil supplied with alternating current. The internal rotating armature is laminated, slotted, and wound with two circuits, one of which is short-circuited to act as a secondary to the eight primary poles, whilst the other is connected up to a disc-shaped commutator. A pair of brushes bears on this commutator, connecting it in series with the field circuit. On starting, the machine acts as a series motor, both armature and field magnetisations reversing simultaneously, thus giving a pulsatory torque always in the same direction. As the speed of the machine increases, the short-circuited secondary winding comes into action and gives a powerful torque which brings the speed up to synchronism. At synchronism, the commutator acts as a rectifier giving a pulsatory direct current to the rotor winding connected to it. This pulsatory direct current sets up direct magnetic poles in the rotor, which react on the A.C. field and make the machine run as a synchronous alternating motor with an internal rotating field-magnet. At synchronism, the short-circuited winding exerts no torque at all but serves, in connection with the self-induction of the rotor-windings, to smooth out, by the currents induced in it, the pulsatory magnetisation of the rotor-teeth and thus render this magnetisation practically constant. C. K. F.

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865. *Motor Switches.* **C. F. Guilbert.** (Écl. Électr. 15. pp. 93–98, 1898.)—The author describes a number of switches for shunt motors. In one the shunt is permanently connected to the brush through a resistance, so that the shunt is never broken. A multiple switch connects the main on to various points on this resistance. As the resistance is cut out of the armature circuit it is put into the shunt circuit. The switch has an off contact. In another switch the shunt is never broken, but after switching off the shunt is short-circuited. In another the switch is held in the full-on position by an electromagnet which carries the shunt-current, but if the main current exceeds a certain value this retaining magnet is short-circuited by another electromagnet which is in the main circuit. The current at which the main magnet works can be adjusted. Two varieties of this switch are described.

R. B. R.

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866. *Leonard System of Motor Control.* (Elect. World, 31. pp. 463–466, 1898.)—A description of the electrical plant of the New York Athletic Club House is given, in which the elevators, four in number, are driven by electromotors controlled on H. W. Leonard's system of varying the supply pressure. A separate generator is used for the supply of each motor, the armatures being connected in series; the fields are excited from the lighting circuits, that of the motor being constant, while the generator field is

varied by means of a controller carried on the elevator car and connected by flexible cables. Reference is made to a description of the elevator machines in Elect. World, 21. pp. 643–646, and 22. pp. 684–685, 1897. A brief account is also given of the system of dumb waiters installed. A. H. A.

867. *Protection of Electric Motors.* **H. H. Cutler.** (Elect. World, 31. pp. 469–470, 1898.)—The author points out that motors can only become dangerously hot by abnormal currents being allowed to flow for an appreciable time. The ordinary fuse is unreliable owing to the cooling effect of varying drafts of air. He then describes a form of enclosed fuse, the distinguishing feature of which is an enclosed air-chamber around the fuse, consisting of a gelatine capsule similar to those used for filling with medicine. The fuse proper is very short and contained entirely within the capsule; copper leads are connected to the fuse and lead out to the terminal caps through closely-packed sand or plaster-of-Paris. The capsule provides a definite amount of air within which the explosion takes place. The force of the explosion is taken up by the sand on each end, and as there is no air and but little metal to feed the arc it immediately goes out. He also describes a circuit heater which depends on the combined magnetic and heating effect of the current. The mechanical construction is similar to the usual type of magnetic circuit-breaker, the chief difference being that the magnet which releases the catch carries only a portion of the current, the rest being shunted by a shunt composed of material whose resistance increases very rapidly as it becomes heated. On starting a motor under load, both motor and circuit-breaker are cold, the resistance of the shunt is low and it carries the largest part of the current: as the current continues to flow the shunt resistance increases and more current flows through the magnet coil, which will finally act should an abnormal current last long enough to be dangerous. An extremely abnormal current or short circuit would cause the circuit-breaker to open instantly. In practice these circuit-breakers are generally so proportioned as to allow an excess current of 50 per cent. to flow for a second. Any current over 60 per cent. greater than the constant current which would finally open the circuit-breaker will do so instantly.
R. B. R.

868. *Step-down Transformers for Niagara.* (Elect. World, 31. pp. 435–438, 1898.)—Four transformers have been installed in the Niagara-Buffalo transmission plant. Three are for actual service, and the fourth is held in reserve in case of accident. Each transformer has a capacity of 850 kilowatts. Three are connected together in a group, giving an aggregate capacity of 2550 kilowatts. The star connection is used on the primaries, the delta connection on the secondaries. The line-voltage is now about 11,000, but will eventually be increased to 22,000. The method of regulation adopted is novel, and is shown diagrammatically in fig. 1 for a single transformer. In each transformer there

is an auxiliary coil wound to deliver approximately 750 volts and a maximum current of 300 amperes. Loops are brought from this coil at regular intervals, and are connected to a regulator-dial. A 75-kilowatt series converter, which is wound for 750 to 240 volts, has its secondary coils in series with the secondary coils of the main transformer, while its primary is connected to the regulator. The regulator is so arranged that any loops from the auxiliary may be connected to the primary of the series transformer, so that the secondary will deliver from 0 to 240 volts, depending on the loops connected to the primary. By means of a reversing switch placed in the primary circuit of the series transformer, its secondary voltage may be added to or subtracted from the secondary voltage of the main transformer.

Fig. 1.

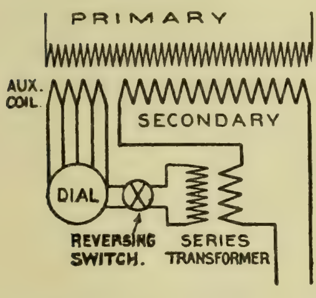
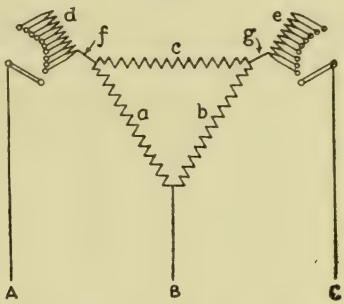


Fig. 2.



Although three-phase currents are delivered at the desired E.M.F., regulators on two phases and only two series transformers are used in each three-phase circuit. The method of accomplishing this is shown diagrammatically in fig. 2. *a*, *b*, and *c* are the secondary coils of the three transformers with delta connection; *d* and *e* are auxiliary coils in transformers *a* and *b*. Loops are brought out from the auxiliary coils, which are connected at *f* and *g* as shown. A, B, and C are the three secondary line wires. From an inspection of the diagram, it is evident that as the dial-handles attached to A and C are turned in corresponding directions through the same angle, the voltages in *a*, *b*, and *c* will all vary together by the same amount.

An efficiency test of one of the 850 kilowatt transformers gives the following results :—

Load.	Efficiency.
Full load.	98·46 °/₀
$1\frac{1}{2}$,, ,,	98·35 ,,
$\frac{3}{4}$,, ,,	98·41 ,,
$\frac{1}{2}$,, ,,	98·10 ,,
$\frac{1}{4}$,, ,,	96·80 ,,
$\frac{1}{10}$,, ,,	92·70 ,,

W. G. R.

869. *Stationary Phase Transformers and their possible Applications.* **G. W. Meyer.** (Zeitschr. Elektrotechn. Wien, 16. pp. 189–193, 1898.)—The author gives an account of some recent devices for obtaining polyphase from single-phase currents by means of *stationary* phase-transformers. Rotary transformers may, of course, be used; but in that case one of the main advantages of alternating currents, viz. the possibility of transforming up or down by means of simple, cheap, and highly efficient apparatus, having no moving parts and requiring no attention, is sacrificed. One important application of such a stationary transformer would be in the case of an electric railway operated by three-phase motors, but supplied with a single-phase current—whereby the necessity of using two overhead conductors is done away with. An ingenious method of dealing with this

Fig. 1.

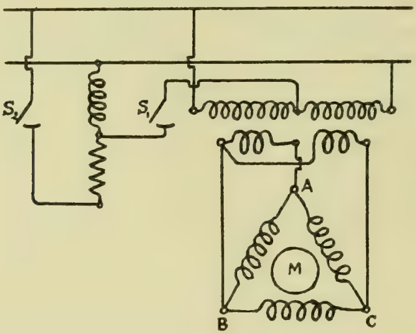
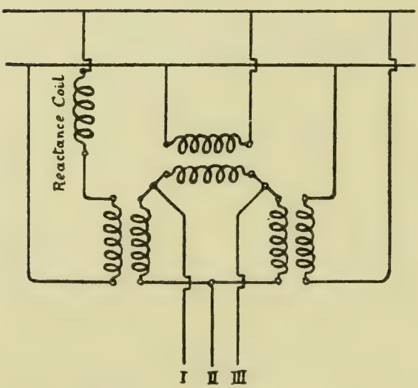


Fig. 2.



problem has recently been patented by the Union-Elektricitäts-Gesellschaft. The three-phase induction motor M (fig. 1) is connected as shown to the two secondaries of an ordinary transformer, the middle point of whose primary winding is *at starting* connected

to the junction of a reactance-coil with a non-inductive resistance, these latter being joined across the mains by means of the switches S_1 and S_2. A phase-displacement is thus obtained which enables the motor to start, after which the switches S_1 and S_2 are opened. The rotor of M is provided with a three-phase winding, and the reaction of this is on the field *when the motor is running* induces an E.M.F. in the portion BC of the winding, so that the motor goes on running as a three-phase machine, although supplied with a single-phase current.—An arrangement patented by T. Marcher in 1895 is next described. It is shown in fig. 2, and is intended to provide two-phase currents between I and II, and I and III, for induction motors, while the ordinary lighting circuit is connected across II and III. The author advocates the use of stationary phase-transformers in combination with independent secondary distributing networks for lighting and power; the motors could thereby be worked at the maximum permissible pressure, which would not be limited by that of the lamps. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

870. *Cost of Electrical Energy.* **H. P. Elliott.** (Canad. Elect. News, 8. pp. 60–61, 1898.)—This paper consists of a detailed analysis of the cost of production of electrical energy as affected by the type of engine used, the cost of coal, and the nature of the load. The case is taken of a 350 kilowatt dynamo supplying energy for lighting; four types of engine, two values for the cost of coal, and three load diagrams are considered. A table of costs in detail is given, together with efficiency curves and load diagrams, and an account of the methods of calculation employed. The result obtained for the total cost per unit generated, with a load-factor of 46 %, and using the best type of engine, is 1·056*d.* with coal at 12*s.* 6*d.* per ton, or 1·32*d.* with coal at 21*s.* per ton. The author concludes that the load-factor has a much greater influence upon the cost of production than either the efficiency of the engines or the price of coal. A. H. A.

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871. *Power Transmission in Mines.* (Zeitschr. Elektrotechn. Wien, 16. pp. 30–34, 41–48, 58–60, 1898.)—In the introductory part of this paper, the author compares the relative advantages and disadvantages of steam, compressed air, hydraulic, and electrical power transmission. The remainder of the paper is of a purely descriptive nature, and is concerned with electrically-driven pumps, fans, winding-engines, haulage machinery, rotary and percussion drills. A. H.

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872. *New System of Distribution.* **C. F. Guilbert.** (Écl. Électr. 13. pp. 486–489, 1897.)—One of the chief difficulties attending distribution of energy by tri-phase currents is due to differences of load on the three circuits. The author proposes to overcome this difficulty as follows:—

Divide each secondary winding of the transformers into five equal parts *a*, *b*, *c*, *d*, *e*. Connect *a*, *b* and *c*, *d* in parallel; join these multiple circuits in series with each other and in opposition to *e*. Each of these three circuits will take from the three primary circuits equal quantities of energy.

The author then proceeds to show that the solution only holds good for a particular phase difference between the secondary currents and E.M.F.s, and so will not, in general, be applicable to practice. W. G. R.

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873. *Thermal Efficiency of Electrical Generating Stations.* **W. S. Aldrich.** (Écl. Électr. 15. pp. 25–27, 1898; Amer. Soc. Mech. Eng. 1897.)—The efficiency of electrical works expressed in terms of watt-hours per pound of coal consumed is always much less than that of other works. According to a table given by

the author, the average value in 1897 was 156·4 watt-hours per pound, whereas in mills, etc., the result was about 450. The author suggests that a comparison made on the basis of watt-hours per calorie expended, or watt-hours per pound of steam used, would be more just, and questions the reality of large losses at low loads. A. H. A.

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874. *Thury's System of Continuous-Current Power Transmission.* **C. Wieshofer.** (Zeitschr. Elektrotechn. Wien, 16. pp. 5–10, 1898.)—The main advantage of alternate over continuous currents for long-distance power transmission lies in the ease of transformation and the greater structural simplicity of the machines. Against this, however, must be set the phase-displacement between E.M.F. and current and the fact that all ordinary forms of alternate-current motors tend to run at or near the speed of synchronism. The author describes Thury's system of power transmission by means of continuous currents ; it is in use at the Val de Travers (1,000 H.P., 10,400 volts, 21 miles), Chaux da Fond and Lock (3,200 H.P., 14,400 volts, 25 miles), Brescia (500 H.P., 7000 volts, 25 miles), and other places. The high E.M.F. is obtained by coupling a number of series-wound generators in series. The drum-winding is used up to 2400 volts, and above that the gramme. Each generator is carefully insulated, the bed-plate resting on porcelain insulators embedded in the foundation by means of a cement of sulphur and powdered glass. The coupling between generator and prime mover consists of a pair of thick rubber disks connected by bolts. Two short-circuiting switches are provided for each generator, one being a hand-switch, the other an automatic switch controlled by a cam on the dynamo-shaft so shaped that when the direction of rotation is reversed the switch immediately short-circuits the machine. The power is received at the distant station by a number of similar series-wound motors connected in series, and used either directly as such or coupled to constant-potential dynamos. Each motor is provided with a special regulator which maintains the speed constant within 2 °/₀ by acting on a shunt of variable resistance connected across the field. A. H.

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875. *Electric Works at Jemmapes.* **A. Soulier.** (Ind. Élect. 7. pp. 107–114 & 130–140, 1898.)—This is a detailed and illustrated description of the installation at Jemmapes, where the distributing system has been changed from three to five wires. The chief point of general interest is the description of the generating plant, which is capable of developing over 27,000 H.P.

W. G. R.

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876. *Multiphase Plant in Railway Shops.* (Elect. World, 31. p. 439, 1898.)—The new locomotive and car shops of the Boston and Maine Railroad, at Concord, N.H., has been installed and isolated plant equipped with multiphase apparatus.

The motors are controlled entirely by means of a quadrant-shaped regulator placed in the primary circuit. Two rows of segments of the regulator being respectively connected with two auto-transformers, thus controlling the speed of the motor by altering the voltage between the primary terminals, since the torque on the secondary of the motor varies as the square of the applied voltage. This method of regulation is similar to, and as successful as, the usual regulation of a series-direct current motor. W. G. R.

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877. *Japanese Cruiser 'Chitose.'* (Elect. World, 31. pp. 442–444, 1898.)—In this vessel, now building for the Japanese navy, a most complete electric installation is being provided, not only for the complete lighting of the vessel, but also electric power hoists for the ammunition. The electric current is produced by three dynamos, each of 32 kilowatts capacity, directly coupled to compound balancing engines. The dynamos are compounded for a constant potential of 80 volts, and are required to deliver their rated output for four hours with a rise of temperature not exceeding 60° F. above that of the surrounding atmosphere. The results of tests are given. The article contains sectional diagrams of the ammunition-hoists. W. G. R.

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878. *Mechanical Features of Electric Traction.* **P. Dawson.** (Engineering, 65. pp. 31–32 & 91–94, 1898; also discussion, 64. pp. 582–583, 1897, & 65. pp. 195–197, 1898.)—In this paper the author describes and discusses the principal details of construction of electric tramways, chiefly with reference to American practice. Numerous tables, curves, and figures are given, including statistics relating to the progress and present state of electric traction in Europe and America; sags, stresses, and other data of span-wires; dimensions and strength of tubular poles; weights of engines and fly-wheels; dimensions, efficiency, etc., of electric-tramway generators; torque and efficiency of motors; and tests of the working of a large generating station. The author emphasises the importance of sound joints in the poles, which have to sustain a side stress of from 500 to 4000 lbs.; details of the method of construction are given, with the tests applied. The design of the car-trucks is described at considerable length, and a list of the conditions to be fulfilled by them in tramway working is given. Various methods of rating traction-motors are discussed, and their special features are detailed. The rating and construction of the engines are considered, and shaft-governors strongly advocated. It is stated that in a large station, of which detailed tests are given, the minimum consumption of coal is 1·67 lbs. per I.H.P. hour or 2·48 lbs. per E.H.P. hour. The design of fly-wheels is discussed, with illustrations of built-up wheels. The discussion turned chiefly upon comparisons of American and English practice.

A. H. A.

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879. *New Heilmann Electric Locomotives.* **C. Jacquin.** (Écl. Électr. 13. pp. 289–305, 1897.)—This is an illustrated description of the new electric locomotives constructed for the Havre line. Two new locomotives have been constructed, each capable of developing 1350 horse-power. Each engine is driven by eight electric motors connected in parallel. The table given below shows the weights of the different parts of these locomotives :—

Body of locomotive	34·0 tons.
Boiler full of water	23·7 „
Steam-engine &c.	9·3 „
Dynamos and motors	40·0 „
Extras	3·0 „
Water and coals	14·0 „
Total weight of locomotive and accessories	124·0 tons.

The older locomotives on the same line have a total weight of 117 tons, and could only develop 700 horse-power. W. G. R.

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880. *Glasgow District Subway.* (Elect. Engin. 21. pp. 70–72, 102–103, 134–136, 172–173, 198–199, 293–295, & 326–328, 1898.)—It is now just ten years ago since the first scheme for the above subway was promoted (viz. in 1887), and the proposals then put forward were for a line to be worked mechanically by cable and embracing only the northern half of the present circle. In 1889 the Company obtained powers to make a tunnel under the River Clyde at Finnieston. The route of the line is, generally speaking, a circle, tapping the chief business and residential portions of the city, and passing twice under the Clyde. The total length of the line is 11,527 yards, or roughly $6\frac{1}{2}$ miles of double track. The tunnels consist of two endless tubes, 11 feet diam., lying side by side.

The reasons why electric traction was not employed are discussed in this paper. Whenever electricity is employed, traction is performed by adhesion—the grip of the wheels on the rails. This, on the Subway, would entail the cars or motors being made sufficiently heavy to surmount the steep gradients under the river, and therefore unnecessarily heavy for traction on the rest of the road. It being almost impossible to get sufficiently powerful motors underneath the cars in the small available space, electric locomotives would be the only other alternative, and these would have to weigh at least 15 tons. Heavy rolling-stock would require heavy permanent way, which, under traction by adhesion, would require more frequent renewal than would be necessary under traction by cable. On the other hand, the cable-system has several advantages peculiar to itself. All the cars on any one cable are thereby linked to each other ; so that the cars going downhill at one point assist in pulling the cars which, at the same time, may be going uphill at another part of the line, thus greatly reducing the demands on the hauling

engine. The greater the number of cars, the greater this compensation becomes. The above reasons are those which at the time induced the engineers to adopt cable in preference to electric traction.

Then came considerations as to lighting both the cars and the stations, and also as to other power-requirements, such as lifts, pumps, etc.; and when all these requirements were considered together, it was decided to adopt electricity for all the above auxiliary requirements, requiring plant having an output of 146,000 watts + 25 per cent. extra for lighting, both arc and incandescent, and power-work over a distance of $6\frac{1}{2}$ miles.

The electrical generating plant includes 4 engines of 120 B.H.P. The dynamos are of the inverted horseshoe type, shunt-wound, direct-coupled to the engines, and each capable of developing 79 kw. The armatures are of the gramme type. Two of the dynamos are arranged for running on the outside wires of a three-wire system, and are wound for an output of 145 amperes at 540 volts; while the other two machines, intended for running in series across the three-wire system, have an output of 220 amperes at 270 volts.

The main switchboard consists of three enamelled slate panels. The main circuits, after passing through automatic cut-outs, are connected to main double-pole throw-over switches, enabling either of the low-tension machines to be put on either side of the three-wire system. The fuse-terminals are arranged so that a plug connects them direct on to the bus-bars, and they are all arranged in duplicate, so that in the event of a fuse blowing a spare one can be immediately plugged in. On each of the feeders running to the four feeding-points are arranged a special combination volt and ammeter, which shows, by means of two pointers on the same scale, both the current in the feeder and the voltage at the power-station end of the feeder. The scale is marked off in amperes, and the pressure-half of the instrument is so adjusted that when its needle is pointing to the same reading on the scale as the current-indicator, the voltage at the station end of the feeder is the correct amount above the normal to give the normal voltage at the other end of the feeders. The current and pressure portions of the instrument are precisely similar, but are totally distinct from one another, the two needles showing one on either side of a vertical scale. A diagram is given of the arrangement of connections on the switchboard.

The distribution throughout is carried out on the three-wire system, the lamps being 230 volt, with a normal 460 volts across the two outside wires. It is claimed for this installation that it is the first station to be laid down on the three-wire system and originally designed for using 230-volt lamps, although it was quickly followed by others.

The cables are all carried on the inner wall of the inside tunnel, on malleable iron bracket supports. The cables are simply laid along these brackets, and then strained up and secured by means

of split wooden blocks bound on to the cable close against the bracket. By this means sag is prevented.

Dampness at first gave considerable trouble, both with the switchboards and with the wiring. All the fittings are mounted upon paraffined teak, as a film of moisture cannot readily form on this material when so treated. All the terminals, too, are mounted on turned teak pedestals well paraffined. Various methods of running the wires were tried, and the most satisfactory plan has been found to be to carry them on small insulators overhead, fixed to the roof of the stations. In some of the drier stations wood casing is still used to a considerable extent.

All the electric-light connections at the various stations are of sufficient size to carry double the number of lamps, it being the Directors' idea to supply current to all their tenants at a cheap rate.

For the purpose of illuminating the cars a pick-up system was adopted, in preference to the use of accumulators, owing to their adding a great dead load to the haulage-engines. It was decided to use two conducting-rails, and to make no attempt to bond the permanent-way rails with a view to using an earth return. These rails are placed along the side of the tunnel, there being not enough clearance at the top, and the space between the rails being occupied by the rope-gear. The general arrangement of the rails is shown in an illustration, the fitting-up of which necessitated the use of 23,000 insulators and 250,000 bolts. The current is picked up from the rails by a somewhat elaborate form of trolley-gear attached to the cars, specially designed to maintain contact on the trolley-rails, irrespective of the motion of the car due to a variation of load or other causes that tend to exert influences on the springs. A drawing is given showing the device employed, consisting of a double trolley-pole, to ensure a steady light.

The interior lighting of the cars consists of four 16 c.p. lamps on the roof. There is a single white headlight with a 16 c.p. lamp, and at the rear there are two red tail-lights, with clear glass inside, which also serve to light the lobby of the cars.

In such an undertaking the pumping arrangements were found to be of paramount importance, and a full description is given of the systems employed.

Up to the present only the Kelvinbridge Station has been fitted with electric lifts, of which the general arrangement is shown in a diagram, and working on the Easton-Anderson and Goolden system. The switch is actuated by a hand-rope passing through the lift-cage, and automatic stops are provided for preventing the cage from overrunning; also an emergency switch worked by the cage, should the latter over-run in consequence of the hand-rope breaking. A magnetic break is provided, so arranged that when the current is on the break is released, but immediately the current is cut off the break is put on.

In designing the signalling arrangements, the point aimed at

was to reduce the labour-bill. It was therefore decided to make the whole of the signalling arrangements semi-automatic, and as simple as possible consistent with the safe working of the traffic. The line is worked on the absolute block system, but without signalmen, the station-masters at their respective stations doing the requisite manipulations. The automatic arrangements and system of working are fully described. There is also an independent system of signals, by means of bells and plungers worked by hand.

L. J. S.

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881. *Test of Chicago Accumulator Tramway.* (Elect. Rev. 42. pp. 311–313, 347–348, 382–384, 1898; and Street Rly. Rev.)—The line consists of 23 miles of track, with a maximum gradient of 9·3 per cent. over a distance of 371 feet, on which it has been found necessary to instal a counterweight system. The whole plant has been designed upon the most approved lines, thus giving a fair trial to accumulator-traction. The batteries are charged off three circuits at different pressures, which are supplied by four six-pole 190-kw. shunt-wound Walker dynamos, coupled to Willans condensing engines. The boilers are water-tube, fitted with mechanical stokers, and supplemented by a Green's economiser. Each battery consists of 72 cells, having five negatives of the "chloride" type and four positives of the "Tudor" or "Manchester" type. The weight of a cell, including plates, electrolyte, and hard rubber jar, is 100 lbs.; the total weight of battery and tray being 7800 lbs. The battery-room is under the car-shed; and the batteries, which are suspended on the car-trucks, are rapidly changed by means of elevators. The discharged batteries are charged successively at 160, 172, and 176 volts. The cars are provided with one 50 H.P. Walker motor. The controllers have five points, by which the four parts of the battery may be coupled all in parallel, half in series and half in parallel, the whole in series with or without resistance, and finally the whole in series, the motor-field being shunted. During last summer 20 motor-cars were operated, often with trailers.

The tests of the road were carried out by G. A. Damon and Prof. Gaylord. The average all-day efficiency (indicated to electrical H.P at switchboard) amounted to 79·3 per cent. The coal had a theoretical evaporative-power of 10·5 lbs. of water, and actually evaporated 6·6 lbs., giving an efficiency of 62·86 per cent., the boiler being underloaded. The economiser was unsatisfactory, owing to unfavourable conditions. The pumps required 5·11 per cent. of the total fuel for their working. The test showed that the engines used 18 lbs. of steam per I.H.P., but they were not working under the best conditions. The total station-efficiency from coal-pile to switchboard was found to be 5·58 per cent. The cost of fuel per net kw.-hour at switchboard is 0·611 cent, this high figure being due to the fact that a high price is paid for a poor coal. Detailed figures are given of the engine and boiler trials. In order to test the performance of the batteries, a complete log was kept of the

charging-room, under somewhat varying conditions, upon two days. The following summary is given:—

Date of test	Nov. 5th.	Nov. 26th.
State of weather	Rainy.	Rainy and cold.
Kw.-hours delivered to switchboard	2,638	2,895
Kw.-hours used by cooling-tower motor	151	174
Net kw.-hours delivered to charging bus-bars	2,487	2,721
Total number of car-miles	1,821·8	1,668·4
Kw.-hours on switchboard per car-mile	1·37	1·63
Pounds of coal per net kw.-hour	6·9	6·44
Price of coal per ton	$1·90	$1·90
Cost of coal per net kw.-hour	0·00655	0·00611
Cost of coal per car-mile	0·00897	0·00996

More energy was required on the second day, owing to a coating of ice on the rails.

In order to determine the efficiency of the batteries a test was carried out upon a $13\frac{1}{2}$-ton car (including batteries), having seating-capacity for 28 passengers. The load consisted of nine observers, the motorman, and conductor; and the car was run as nearly as possible under the conditions of an actual trip, at an average speed of 11·84 miles per hour. The results over a practically level road, with a battery that had operated over 8000 miles, were an efficiency of 53·6 per cent. for the first charge and discharge, and 62·32 per cent. for the second charge and discharge. The second of these figures is the more reliable, and the difference between the two is due to the fact that the charging of the battery was left to the regular operators, who used their judgment as to the pressure, and as to when the battery was fully charged. The maximum discharge-rate during acceleration was found to be 220 amperes per cell, all the cells being in series.

It is pointed out that these tests do not demonstrate the best results that may be expected from accumulator-traction, as they were not made with that object. With the introduction of improvements, the cost of fuel per car mile should fall below 0·5 cent. Figures of maintenance would be premature. The batteries have operated from 8,000 to 14,000 miles, and are standing the service remarkably well. W. R. C.

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882. *Three-Phase Traction at Zermatt.* **W. Hönig.** (Zeitschr. Elektrotechn. Wien, 16. pp. 89–92, 1898.)—The paper contains a description of the electrical equipment of the Zermatt-Gornergrat mountain-railway. The author is of opinion that, in spite of the objections raised against three-phase traction on the score of two overhead wires, the system is bound to come into more general use. The total length of the line under consideration is about $5\frac{1}{2}$ miles, the generating station being about a mile distant from Zermatt. The generating plant consists of three sets of 250 H.P.

three-phasers (5400 volts at 40 ~ per sec.) coupled elastically to Pelton water-wheels running at 400 revs. per min. Two sets are always in use, the third being a reserve. The power is transmitted along three 5½-mm. wires to three transformer sub-stations of 180 kilowatts capacity each, and is there transformed down to 540 volts, at which pressure it is fed into the line (two 8-mm. wires). Each locomotive carries two three-phase non-synchronous motors of 90 H.P. each, running at about 800 revs. Double-reduction helical gearing (giving a ratio of 12:1) is used, the pinions driven by the motors working on a rack laid in the centre of the track. Vignoles rails, with Chicago rail-bonds, are used. The steepest grade is 1 in 5. The rotor-winding is connected to three contact-rings, and by means of a resistance common to the two rotors the speed may be varied. The motors will start under full load without drawing more than the normal current from the line. When running down-hill the motors may act as generators, whereby the plant at the generating station might reach a dangerous speed. This is provided against by an artificial load at the station, which is automatically thrown into circuit as soon as a certain limiting speed is reached by the water-wheels. The railway is to be opened for traffic in July. A. H.

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883. *The Walker Tramway Controller.* **J. Reyval.** (Écl. Électr. 15. pp. 45–48, 1898.)—This controller differs from the ordinary types fitted with magnetic blowers, inasmuch as each contact where an arc can take place is fitted with a special magnetic circuit consisting of solenoids without iron. The controller is so constructed that there is no uninsulated piece near the contacts where the arc is formed: so that no dangerous earths can take place. The arc, moreover, is blown in a direction perpendicular to the axis of the cylinder, and can therefore neither burn the insulation nor establish a short-circuit between two adjacent contacts. The magnetic flux produced by the solenoids is proportional to the strength of the current through them, and consequently to the arc to be blown; whereas, with those blowers employing electromagnets wound on polar projections, the saturation of the iron limits the action of the blower when the strength of the current is very strong and at the moment when the arc is most dangerous. The solenoids are only put in circuit at the moment of coming into action, thus effecting a saving of energy. The brushes and contacts are, moreover, left uncovered in order that they may be easily inspected and repaired. The weight of two such controllers and one rheostat, for a car of 25 to 30 H.P., amounts to 220 kg. L. J. S.

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884. *Efficiency of Tramcar Motors.* **E. G. Fischinger.** (Elektrotechn. Ztschr. 51. 1897.)—Experiments were made on one

Constant Pressure, 500 volts.

Motor with Reduction Gearing.										Motor alone.							
Exciting current, full armature current.					Exciting current, half armature current.					Exciting current, full armature current.				Exciting current, half armature current.			
Current, in amperes.	Speed of motor, in revs. per min.	Speed of car, in miles per hour.	B.H.P.	Efficiency, %.	Current, in amperes.	Speed of motor, in revs. per min.	Speed of car, in miles per hour.	B.H.P.	Efficiency, %.	Current, in amperes.	Speed of motor, in revs. per min.	B.H.P.	Efficiency, %.	Current, in amperes.	Speed of motor, in revs. per min.	B.H.P.	Efficiency, %.
76·2	376·5	7·0	34·2	65·7	77·0	452·0	8·4	40·8	77·8	71·0	385	33·3	69·0	74·0	480	41·8	83·0
70·0	384·0	7·1	32·0	67·0	71·8	459·0	8·6	38·4	78·0	65·0	400	32·2	73·0	69·0	485	39·0	83·0
64·8	394·0	7·3	30·1	68·5	67·0	469·0	8·7	35·9	78·0	59·8	412	30·2	74·0	64·2	495	36·3	83·0
59·5	404·0	7·5	27·9	69·0	62·8	482·0	9·0	33·5	78·0	54·8	418	27·8	75·0	59·7	510	33·7	83·0
53·8	416·5	7·8	26·2	71·8	58·3	497·0	9·3	31·2	78·8	49·3	436	25·8	77·0	54·0	523	30·8	83·8
48·6	432·0	8·1	24·0	72·5	53·8	514·5	9·6	28·6	78·5	44·0	452	23·6	79·2	49·2	538	28·2	84·2
43·6	447·0	8·3	21·6	73·0	48·4	537·0	10·0	26·2	79·5	38·8	466	21·3	80·2	43·6	561	25·5	85·6
38·2	462·0	8·6	19·2	74·0	43·3	560·0	10·4	23·4	79·5	33·8	485	18·6	80·5	38·8	586	22·4	85·0
33·4	479·5	9·0	17·1	75·0	37·4	587·0	10·9	20·4	80·0	29·0	508	16·9	80·7	33·7	621	19·6	85·0
28·4	504·5	9·4	14·1	73·0	32·0	627·5	11·7	17·4	80·2	23·3	535	13·1	83·0	28·5	675	16·5	84·8
23·7	547·0	10·2	11·4	71·0	26·2	693·0	12·9	14·4	81·0	18·7	575	10·0	78·5	23·7	763	13·3	82·0
18·0	612·5	11·3	8·5	69·5	20·8	798·0	14·9	11·0	77·5	13·6	650	6·8	73·5	18·3	940	9·8	79·0
15·8	647·5	12·1	6·7	63·0	18·3	904·0	16·8	9·4	75·2	11·0	745	5·2	69·8	15·8	1095	7·7	72·0
12·9	738·0	13·7	5·2	59·0	15·2	1069·0	19·9	7·4	71·5	8·4	940	3·3	57·0	11·7	1460	4·4	55·0
10·2	939·0	17·4	3·3	47·0													

of the motors in use on the Mulheim Tramway, measurements being taken after the motor had worked 8 hours. The results are given in the table (p. 463). The gear-wheels were lubricated with valvoline oil, and showed an efficiency of from 90 to 97 %, the smallest efficiency being when transmitting large powers at small speed. With grease as lubricant the efficiency was less, except in the case of small powers at slow speeds. G. H. Ba.

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885. *Electric Traction on Canals.* (Elekt. Runds. 15. p. 111, 1898.)—A brief account of experiments in this direction conducted in France. Two methods have been tried. In the one, a special form of electric car is propelled along the towing-path, and is connected to the barge by a rope. In the other, a detachable screw-propeller worked direct by an electric motor is used. The current in either case is supplied by an overhead conductor and trolley. A. H.

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886. *Electric Car-Wiring.* **E. C. Parham.** (Amer. Electn. 10. pp. 171–172, 1898.)—In previous articles the author dealt with all the connections on the car, excepting several inside the controller. In order to proceed with the test the author deals with the car-wiring diagram of the system in question, showing the order in which the current from the trolley enters the several devices on the car, and the relation borne by the terminals of these devices to the lettered or numbered binding-posts on the controller. The order in which the current enters the several devices depends on whether the armature or the field is earthed. Some systems earth one and some the other. The advantages and disadvantages are discussed. On all systems of wiring it is customary to designate the terminals of the various devices by means of the initial letters of their names. These letters are further modified to distinguish the different leads coming from the same device, and, further, the letters are stamped on the controller collecting posts, so that the most inexperienced wireman may readily see to what part of the controller the variously tagged hose wires should go. An illustration is given of the most common system of lettering, and examples given of the various faults which may happen and the methods of locating them. Points about an equipment most apt to give open circuit troubles are :—poor connection between trolley-stand and roof-wiring ; defective hood-switch ; loose controller connection, controller finger making no contact ; resistance-coil burnt out ; motor field or armature lead burnt off ; a blown fuse ; weak brush springs, short brushes, brushes tight in holders, or absence of brushes altogether ; ground-terminal burnt off ; loose two-way connector ; and a dirty or dead rail. The symptoms indicating most of these faults are dealt with. L. J. S.

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887. *Welsbach Incandescent Lamp.* **A. M. Gibson.** (Elect. Rev. 42. pp. 504–505, 1898.)—The author gives some particulars regarding Welsbach's recent invention. Two bodies—osmium and thoria—are used in the preparation of the lamp filaments. The efficiency of such lamps has been stated to be less than 2 watts per candle. Several methods of preparing the filaments are described. The author states that although the electrolytic method of obtaining a coating of osmium or thoria is by far the cheapest, this method is only vaguely alluded to in Welsbach's patent specification, while those described by him are little better than laboratory processes quite impracticable on a large scale. He concludes by saying that the facts on which Welsbach's patent is based have been known to experts for some time past. A. H.

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888. *Welsbach Incandescent Lamp.* **J. R.** (Écl. Électr. 15. pp. 190–192, 1898.)—In a recent Hungarian patent Auer v. Welsbach describes various methods of coating or forming glow-lamp filaments with substances capable of increasing their efficiency, as in incandescence gas-lighting. Metallic osmium and thoria (thorium oxide) are the most suitable materials. To obtain a filament of osmium a fine platinum wire (0·02 mm. diam.) is repeatedly heated to redness either in an atmosphere of osmium tetroxide and hydrocarbon vapour, or after immersion in a solution of osmic acid and osmium sulphide (*sic*). The adherent very thin layers of metallic osmium thus deposited in the course of about 100 operations form a tough tube, from which the platinum core is then volatilised by means of a strong current. Instead of platinum, animal or vegetable fibres may be used; they are dipped in a solution of osmic acid containing sugar or gum, and then dried and heated to redness in a reducing atmosphere. The filaments thus obtained are finally bent into shape, and heated repeatedly by a strong current in alternate atmospheres of moist hydrocarbon and osmium tetroxide vapours. Filaments may also be made of a paste of guncotton and amorphous osmium or osmium tetroxide, and an electrolytic method of depositing osmium is mentioned but not described. Platinum wires are coated with thoria in the same way as with osmium, by alternately moistening the wire with thorium nitrate or other decomposable salt, and heating; but in this case the platinum core is permanently retained, and it is noteworthy that thus coated it bears a temperature and current which would fuse an uncoated wire. An alloy of platinum and osmium, with or without other metals of the platinum group, may be substituted with advantage. The efficiency of some of these new "incandescence" glow-lamps is stated to be as high as 2·0 to 1·5 watts per candle-power. J. W.

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889. *Enclosed Arc-lamp of the Allgemeine Elektricitäts Gesellschaft.* (Zeitschr. Elektrotechn. Wien. 16. pp. 140–141, 1898.)—

The details of construction of this lamp are not given, except in so far as they can be gathered from two photographs and a description of the method employed of inserting fresh carbons in the lamp. The time of burning of a 4-A. lamp is about 150 hours, a 5-A. lamp about 130 hours, a 6-A. lamp about 110 hours, when the lamps are burnt in periods of about 5 hours at a time. The potential difference of the arc is about 75 V., a resistance being generally arranged in series with it, sufficient to enable the lamp to work on 100–110 V. circuits. For the upper carbon a solid (homogeneous) carbon 13 mm. dia. and 300 mm. long is employed; the lower carbon also consisting of a solid carbon 13 mm. dia., but 150 mm. long. It has been found to be important that the inner globe and carbons should be thoroughly dry, otherwise the light flickers. C. K. F.

TELEGRAPHY AND TELEPHONY.

890. *Telegraphy.* **S. P. Thompson.** (Soc. Arts Journ. 46. pp. 453–460, 1898.)—Under the heading of "Telegraphy across space" three generic systems are considered:—(1) Conduction methods, depending upon the use of water-areas or the earth as a means of conveying electricity from sender to receiver. (2) Induction methods, electro-static and electro-magnetic. (3) Hertz-wave methods. The paper includes useful historical data, and particulars of distances traversed by the various systems. R. A.

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891. *Signalling by Rotating Magnetic Field.* (Elettricità, Milan, 17. pp. 199–203, 1898.)—This article describes an apparatus devised by the Allgemeine Elektricitäts Gesellschaft of Berlin for the transmission of telegraphic messages. The transmitter is a generator of polyphase currents, and consists essentially of a coil in the shape of a Gramme ring, with three line-wires attached at points 120° apart. The current from a battery, not necessarily of constant electromotive force, is supplied to contacts at the ends of a rotating diametral arm, and sets up sine-currents of different phases in the three line-wires. These currents are sent to the receiving instrument and conducted to three electromagnets arranged so as to give a rotary magnetic field; a magnet pivoted in this field sets itself in a direction corresponding to that of the rotating arm of the transmitter. If the latter be pointed to any letter or sign on the circumference of the transmitter, the magnet of the receiver will indicate the same letter or sign on the circumference of the receiver. Separate transmitting and receiving instruments are depicted, also a diagram of an instrument in which both functions are combined. It is pointed out that the system can be applied with advantage in signalling from the deck to the engine-room, or other parts, of a ship. J. L. H.

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892. *Hertz Waves and Wireless Telegraphy.* **O. Murani.** (Elettricità, Milan, 17. pp. 231-234 & 245–247, 1898.)—An abstract by Prof. A. Volta of the author's paper read before the Italian Electrotechnic Association at Milan. It contains a brief description of the theory of electromagnetic waves and an account of the experiments of Hertz; this is followed by a short sketch, in historical order, of discoveries and researches which have contributed to the success of the recent practical developments by Marconi. J. L. H.

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893. *Rotary Decoherer.* **H. Rupp.** (Elekt. Zeit. April 14th, 1898, p. 237, & Elect. Rev. 42. p. 535, 1898.)—The filings-tube is rotated on its principal axis by the motion of the Morse slip. Contact is made by small brushes, one at each end of the tube. This apparatus takes the place of the electric tapper-back. A sketch is given to show the switching arrangements for the calling-up circuit and the Morse instrument. R. A.

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894. *Telephone Call System.* (Elekt. Runds. 15. p. 97, 1898.)—The following arrangement, introduced by R. Stock & Co., of Berlin, does away with the necessity of any talking on the part of the operator in a telephone exchange. In front of a microphone at the exchange is placed a small electric trembler giving about 4 beats per second. The secondary of the microphone induction-coil is connected on one side to earth, and on the other to a metallic bar supporting the front row of subscribers' plugs. When a subscriber calls up, the operator inserts the corresponding back plug into the subscriber's jack, and thereby earths his line through the microphone-and-trembler signalling arrangement. The subscriber is thereby advised that he is being attended to. The operator immediately afterwards lifts the front plug, and by holding a notch cut in it against a metallic ring connects her listening apparatus to the calling subscriber's line, while the signalling arrangement is at the same time disconnected. The cessation of noise in his receiver tells the subscriber that the operator is ready to receive instructions, and he states the number of the subscriber wanted. The operator then inserts the front plug into the jack of the subscriber required, and by pressing a key once more momentarily connects the calling subscriber's line to the signalling apparatus. He then knows that through connection has been established. Should the subscriber wanted happen to be engaged, the operator simply removes the back plug from the calling subscriber's jack and then replaces the front plug on the contact-bar. The calling subscriber therefore receives no second signal, and interprets this to mean that the subscriber wanted is engaged.
A. H.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

AUGUST 1898.

GENERAL PHYSICS.

895. *Rigidity of Quartz Fibres.* **S. J. Barnett.** (Phys. Rev. 6. pp. 114–120, 1898.)—Quartz in the form of fibres of about 0·08 cm. diam. has a coefficient of rigidity at ordinary temperatures of about $1{\cdot}46 \times 10^{11}$. The coefficient does not vary with time. The coefficient *increases* with rise of temperature. A. Gs.

896. *Maximum Density of Alcohol.* **P. Moretto.** (N. Cimento, 4. 6. pp. 198–204, 1897.)—The author gives the maxima of density, obtained by De Coppet's method, of a number of solutions of methyl alcohol in water. For a 1 per cent. solution this maximum occurs at $4^{\circ}{\cdot}14$ C. For all other solutions it occurs at a lower temperature.
E. E. F.

897. *Density of Small Volumes of Gases.* **T. Schlœsing, Jnr.** (Comptes Rendus, 126. pp. 476–479 & 896–899, 1898.)—Gives some results of measurements with his gas manometer, which is 1460 times more sensitive than a water manometer. It consists of two long vertical tubes communicating at the top and bottom. One of them is divided into three parts by two side-tubes, which have many convolutions in a horizontal plane, so as to form a space in which gases can freely mix without affecting the main tube. The middle portion is filled with the gas to be examined, the bottom portion with CO_2, and the top and the entire other tube with air. As soon as the cock at the top is opened, equilibrium is established between the two tubes by a displacement of the imaginary surface of separation between the various gases. This surface of separation travels along the serpentine side-tubes, and does not affect the pressure or the composition of the gas in the main tube. The pressure is measured by letting

mercury into the other main tube and noting its level. The whole system forms a set of communicating tubes with one gas balancing three others in due proportions. The apparatus is useful for determining the densities of gases which, like argon, are only obtainable in small quantities, and also for investigating minute differences of pressure, as in a gas flowing along a tube. E. E. F.

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898. *Sun-spots and Variation of Magnetic Elements.* **W. Ellis.** (Roy. Soc. Proc. 63. pp. 64–78, 1898.)—The paper forms a continuation of one published previously on the same subject. The data are obtained for the period 1841–1896, the magnetic elements being derived from the Greenwich reports and the sun-spot data from those published by Prof. Rudolf Wolf. The three curves—number of sun-spots, diurnal range of declination, and diurnal range of horizontal force—are of the same general form, the maxima and minima occurring at the same time for all. The values of the maxima and minima also agree; thus, when there is an exceptionally high maximum in the sun-spot curve there is also an exceptionally high maximum in the declination and horizontal-force curves, and so on. The author concludes that these three phenomena must therefore be due to some common cause.

W. W.

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899. *Photography of Chromosphere.* **H. Deslandres.** (Comptes Rendus, 126. pp. 879–882, 1898.)—The author who, at the same time as Hale of Chicago, suggested that the violet lines H and K of calcium-vapour were bright in the spectra of faculæ, describes his arrangement for applying this fact to the problem of photographing the forms of faculæ and the chromosphere. The instrument, which he terms the "spectroheliograph," consists essentially of a spectroscopic train comprising slit, collimator, prism, and telescope, but with a second slit replacing the usual eyepiece at the focus of the telescope. This forms then an apparatus by means of which light of any desired wave-length can be isolated from the rest of the spectrum. An image of the sun is formed by a condensing-lens on the first slit, and a photographic plate placed close to, but not connected with, the second. If then the whole spectroscope is traversed so as to cause the first slit to cross the entire solar image, the light emerging from the second slit will print on the plate the images of whatever parts of the sun emit bright lines, viz. the lighter parts we call faculæ. In this way the author has got excellent plates showing the distribution of faculæ over the whole of the sun's disc. For the chromosphere, which is relatively feebler, the photosphere is obscured by means of a disc slightly larger than the visible image on the slit, and the rate of motion of the spectroscope lowered; and by this method the whole of the prominences etc. surrounding the sun are obtained at one exposure.

It is found that a great dispersion is not necessary, as the

K line of calcium is very broad and dark that it acts as a preventive to any other light passing through the second slit and so rendering the image obtained impure.

In his first apparatus, Deslandres used an image of the chromosphere 50 mm. in diameter, but has lately replaced the image-lens by one giving an image of 85 mm., so that details are much more clearly shown. He finds, from a study of the forms and numbers of the faculæ, that they follow a similar law to that so well known in the case of sun-spots. The photographs on the enlarged scale show much more of the grained structure of the solar surface, which has hitherto only been accurately portrayed by Gaussen. C. P. B.

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900. *Temperature of Europe.* **Van Rijckervorsel.** (Phil. Mag. 45. pp. 459–466, 1898.)—The author has drawn curves showing the mean values of the temperature for each day of the year, obtained from long series of observations, for many stations in Europe. He finds that there is a characteristic form of the curve for each station, which in some cases has persisted for two centuries, the characteristic curve varying from station to station, but in a regular manner. Some of the smaller maxima and minima are most astonishingly persistent and appear in the curves for many stations. The summer peak is very much flattened at stations on the Western coast, while it becomes steeper and steeper towards the Eastern portion of the continent. W. W.

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901. *Annual Range of Temperature at Rome.* **E. Bortolotti.** (Roma, R. Accad. Lincei, Atti, 7. pp. 121–128, 1898.)—The author discusses the values for the temperature at Rome during the years 1855–1894, and calculates what is the chance that the temperature of any particular month may differ from the mean value by given amounts. W. W.

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902. *Harmonic Analysis.* **E. J. Houston** and **A. E. Kennelly.** (Elect. World, 31. pp. 580–581, 1898.)—The method proposed by the authors depends on the following proposition:—If an odd number w of semi-wave-lengths of a simple sine curve be divided by straight lines perpendicular to the horizontal axis into p strips of equal width, and if p be >1 and prime to w, the difference between the sums of the areas in alternate strips is zero (*i. e.*, sum of odd strips—sum of even strips$=0$); if, however, $p=w$, *and the strips commence at the zero line*, then sum of odd strips—sum of even strips$=p$ times area of one semi-wave. From this is derived the following rule for analysing any graphically given wave into its simple harmonic components, say

$$A_1 \sin a + A_3 \sin 3a + A_5 \sin 5a + \dots$$
$$+ B_1 \cos a + B_3 \cos 3a + B_5 \cos 5a + \dots$$

To find any given coefficient, such as A_3, in the sine series, divide the curve into 3 equal strips, commencing at the zero point, and find the summation-difference S by planimeter, or by counting the number of little squares included in each strip. Then

$$A_3 = \pi S/L,$$

where L is the length of the given complete wave. Again, to find any coefficient in the cosine series, such as B_5, divide the semi-wave into 5 strips, *commencing at a point half a quintuple-frequency semi-wave-length from the zero point.* Then, S denoting as before the summation-difference,

$$B_5 = \pi S/L.$$

A. H.

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903. *The Jervis-Smith Tramway Chronograph.* (Engineering, 65. pp. 692–693, 1898.)—The tramway chronograph, whose name indicates the general construction of the instrument, measures the velocities of projectiles. A carriage, holding a smoked glass plate in a vertical position, rides on a rail about 5 feet long which is levelled by means of three screws. A tuning-fork and a number of styles are fixed on a special standard. Each style is carried by an aluminium arm attached to the armature of an electromagnet, which is released when the projectile passes through a screen. In order to use the instrument, the carriage is pushed home against a piston which stretches two spiral springs. On releasing the trigger, the carriage begins to run; it closes the firing circuit on its path, and is finally arrested by a brake strap of leather. When the records have been obtained, the times are measured by projecting with a T-square the breaks on the lines traced by the styles on to the time-record as traced by the tuning-fork. H. B.

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904. *Wave-Resistance of a Ship.* **J. H. Michell.** (Phil. Mag. 45. pp. 106–123, 1898.)—This paper gives a general solution of the problem of the waves produced by a ship moving with uniform velocity into deep still water, on the assumption that the ship is long and deep in comparison with its breadth. Practically, the solution obtained may be regarded as the first of a system of successive approximations which can be carried out in the same manner. A law of the resistance arising from the alteration of pressure on one element of the ship due to the disturbance created by another element is developed, and the result brought into comparison with the famous experimental results of the Froudes on the interaction of bow and stern waves. In connection with the resistance of high-speed boats, now attracting so much attention, it is proved that the wave-resistance in deep water ultimately vanishes as the speed is increased.

An example of the numerical calculation of the resistance of a ship of known form is appended, and there is also a simple theory given of a ship in shallow water. AUTHOR.

LIGHT.

905. *Propagation of Waves along a Periodically Loaded String.* **C. Godfrey.** (Phil. Mag. 45. pp. 356–363, 1898.)—The system considered consists of a heavy inextensible string under tension extending from $-\infty$ to $+\infty$. From $-\infty$ to 0 it is free from loads; from 0 to $+\infty$ it is loaded at equal intervals with equal massive particles. Simple transverse waves are travelling from $-\infty$; the steady vibration of the system is investigated. As the wave-motion continually impinges on the system of masses, some of it is reflected, some transmitted. It is found that the amount of transmission (and reflexion) depends on the wave-length in a discontinuous and quasi-periodic manner. The results may be stated in optical phraseology as follows:—A mixture of light of all wave-lengths impinges upon a solid of periodic structure. The light is analysed by a spectroscope after transmission through a considerable thickness. We shall find bright bands, narrow in comparison with the distances between them, their lower edges ranged harmonically; each band will be faint on the lower side and terminate abruptly at the upper edge. The width of the bands diminishes as we ascend the scale of frequency. Their lower edges correspond to the proper periods of the intermolecular spaces. If we view the light reflected, we shall find total reflexion corresponding to the frequencies of the dark bands of the transmission-spectrum; for these wave-lengths there will be reversal of phase on reflexion. In the above statement the word "light" must be taken to include radiation which lies outside the range of vision. AUTHOR.

906. *Transparency of Bismuth in a Magnetic Field.* **H. Buisson.** (Comptes Rendus, 126. pp. 462–463, 1898.)—In the electromagnetic theory of light the transparency of bodies is linked with their electric conductivity, the coefficient of absorption being, to a first approximation, proportional to the square root of the conductivity. The author endeavours to find a variation of transparency in consequence of an intentional variation of the resistance of bismuth by means of a magnetic field. But experiments made with electrolytic bismuth in transparent sheets, exposed to a field of 15,000 units, which increases the resistance 60 per cent., fail to discover any variation of the transparency. It is evidently not the resistance to continuous currents or to slow oscillations which determines the opacity of a substance to light. E. E. F.

907. *Hefner Lamp.* (Elect. Rev. 42. pp. 759–760, 1898.)—The article contains a detailed description, with illustrations, of the Hefner standard. Curves showing the variation of its intensity with barometric pressure and humidity are given. From these

it appears that such changes are under normal conditions extremely small. On the other hand, the intensity is much influenced by the amount of oxygen present in the air in which the flame is burning; hence the importance of using the standard in well-ventilated spaces. A. H.

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908. *Action of Metals etc. on a Photographic Plate.* **W. J. Russell.** (Chem. News, 77. pp. 167–170, 1898.)—The paper describes numerous experiments made to investigate the statement made in the Chem. News, 75. p. 302, that certain metals, copal, printing-ink, etc. had an action similar to light on a sensitised film. The active constituents of the organic bodies mentioned were found to be oil and turpentine. Further experiments showed that the following were active substances:—Vegetable and essential oils, paraldehyde, benzaldehyde, guiacum, cinnamon, spirits of nitre, eau-de-cologne, and terebene. The activity seems to depend on the reducing power: thus, linseed oil is very active, while olive oil, which has a far less reducing power, is only slightly so. Also oxidised bodies nearly related to the terpenes—such as terpinol, camphor, and thymol—are inactive. With some of these active bodies solarisation can be obtained. Among the metals, zinc, cadmium, magnesium, aluminium, and fusible metal are active; while lead, nickel, tin, silver, sodium, and mercury are inactive. A very slight trace (so small as one three-hundredth per cent.) of zinc is sufficient to make mercury highly active. Again, alcohol when pure is inactive, but after being in contact with zinc becomes active, this activity remaining after filtration and to a certain extent after distillation. Zinc after long exposure to the air is inactive, and is more active the cleaner its surface.

The experiments show conclusively that the action is due to a vapour emanating from the bodies; the active vapour can, for instance, be carried by a stream of air against the plate. Inactive substances such as cardboard can be impregnated with the vapour so as to become active. The vapour is capable of passing through sheets of various substances, such as gelatin, celluloid, collodion, goldbeaters'-skin, paper, tracing-paper, parchment, and gutta-percha. The transparency is the same to the vapour from the metals or from the other active bodies. Glass, selenite, and mica are quite opaque to the action.

To test the porosity of the transparent substances, the power of hydrogen to diffuse through them was tried. Diffusion takes place through tracing-paper and goldbeaters'-skin; but through thin gelatin and celluloid there was no sign of diffusion until after three days. Increase of temperature greatly increases the activity of both the metals and the organic bodies. The time of exposure in the experiments varied from a day to two months. G. H. Ba.

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909. *Photographic Development.* **R. Colson.** (Comptes Rendus, 126. pp. 470–473, 1898.)—The effect of touching the

sensitive plate with the hand or with any warm conductor during development is to produce streaky black marks, due to acceleration of the developing process at the points touched, and diffusion from the more concentrated developer. This diffusion may also take place at the border between a very bright and a very dark portion of the image, since the developer above the dark portion is attenuated, and then rehabilitated by diffusion. Hence the dark portion is blackest at the border, where the developer is fed from the white portion. This happens when the developer is either very rapid or is allowed to stand. The author studies the effect in detail. Some supposed Röntgen-ray effects may possibly be attributable to this source of error. He describes a process of "confined development" where the plate is covered by a thin layer of developer surmounted by a glass plate. The result is to harden the contrasts, which is useful in line drawings. E. E. F.

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910. *Radiation Phenomena in a Magnetic Field.* **T. Preston.** (Phil. Mag. 45. pp. 325–339, 1898.)—Gives a general account of the modifications which the spectral lines of various substances suffer when the source of light is placed in a strong magnetic field. The paper is accompanied by a plate, reproduced from an actual photograph, of the spectral lines of cadmium and zinc. This plate shows the triplets formed when the radiation travels across the lines of force, and the doublets formed along the lines of force as well as the polarisation of the constituents of the triplets. In addition, some of the modified lines show as quartets across the lines of force. This and other deviations from the normal triplet type of effect are considered in the paper, and are thought to be sufficiently accounted for as the effects of absorption in the outer vapour of the spark; but this point is not considered as conclusively established.

Measurements are given which show that the quotient e/m is not constant, but is some function of the wave-length not yet determined, or else it possesses a set of values for each substance which correspond to sets of spectral lines, the grouping of which has not yet been effected. Gases and magnetic substances are also considered and other details are given in the paper, which must be referred to for fuller information. AUTHOR.

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911. *Zeeman Effect.* **A. Garbasso.** (N. Cimento, 4. 6. pp. 8–14, 1897.)—Instead of postulating an action on the electrons, the author supposes that the magnetic field acts directly upon the vibrating atoms, producing a kind of damping effect. This widens the spectrum line into a band, with polarised edges. In the case of rays proceeding along the lines of force, they must traverse the air contained in the perforation of the magnet-pole, which is in an optically active state. The rays, to begin with, are plane-polarised, and their vibration may be considered as the

resultant of two circular vibrations in opposite directions. One of these is accelerated by the air, and the other is retarded, giving rise to the edges circularly polarised in opposite directions, as observed by Zeeman. E. E. F.

912. *Röntgen Rays.* **G. G. Stokes.** (Mem. & Proc. Manchester Lit. & Phil. Soc. xli., 1897.)—The method of ascertaining the source of Röntgen rays by finding the points from which the directions of Röntgen rays (as determined by means of shadows) apparently diverge is not conclusive: as an experimental fact, the Röntgen radiation is more abundant along the normals to the fluorescent surface than in any other directions; but it does not follow that their source is the point where these normals, if produced backward, converge. Röntgen appears to have correctly stated that the rays come from the place where the kathode rays strike the glass.—Röntgen rays seem to travel in the ether; but how? The transparency of so many opaque substances to them would not be of great consequence if it stood alone: the distinct outlines of shadows and the absence or almost complete absence of diffraction raise the question of transversal or longitudinal vibrations. Polarisation would show the vibrations to be transversal: the apparent absence of it with tourmalines is not conclusive; and polarisation by reflexion is not available. Becquerel's rays being polarisable, Galitzin and v. Karnojitski having obtained some indications of polarisation with Röntgen rays, and Green's argument against the existence of longitudinal vibrations in the ether being as valid in the case of Röntgen rays as in that of light, the conclusion is that the perturbations are transversal.—The kathode rays are the parents, so to speak, of the Röntgen rays: these are either molecular streams or perturbations propagated in the ether. Kathode rays are usually slightly visible from one side (unless the rarefaction is extreme) as a faint blue light: this might be due to ether-perturbations encountering molecules. But the difficulties of the ether-theory are extreme: the mechanical effect of the kathode rays, their rectilinear course at right angles to the kathode, their deviation by electric, magnetic, and electrodynamic forces. The principal difficulties of the molecular-stream theory are:—(1) Kathode rays will not pass through extremely high vacua; but kathode rays passing through lower vacua will, after passing through aluminium, continue their course (Lenard) in the highest vacua. Lenard thinks the highest vacua may be considered as perfect vacua; the author does not: there is always a blue halo round the bright patch on the phosphorescent screen, and there is always some effect analogous to opalescence; the vacuum is not perfect. (2) How could kathode rays, if molecular, pass through an aluminium window? It is not absolutely clear that they do: compare a sheet of copper inserted between the electrodes in an electrolytic cell; the second surface of the aluminium window may act as a fresh kathodic surface.—The deviation of the kathode rays by electric etc. forces is difficult to explain on the ether theory, but

is quite natural on the material theory, for a charged molecule at a high velocity acts like a current and is similarly attracted or repelled.

Adopting, then, the molecular-stream theory, each molecule, when it impinges on the antikathode, produces a perturbation of the ether, either through its momentum or through its static charge (whatever that may really mean); and the perturbation is propagated through the ether in all directions, in a spherical wave if the medium be indefinite, and transversal if the medium be not compressible. Now, instead of considering undulatory or periodic disturbances, consider one single pulsation: this consists of two half-waves which need not be identical, but the integral of the perturbation in one direction must be equal and of opposite sign to the integral of the perturbation in the opposite direction. Of such single pulsations, a succession of them, independent of one another, each starting from the point where a molecule from the kathode has jolted against the antikathode—of such may Röntgen radiations be made up. The numbers of such pulsations or single throbs would be immense even at the highest vacua obtainable. This conception enables us to explain the characteristic features of Röntgen rays:—I. *The absence of diffraction*, or rather its almost entire absence. In a single pulsation the absence of diffraction will be more complete the greater the obliquity and the less the thickness of the portion of the ether disturbed by the passing wave. If then the perturbation of the ether caused by the impact of the molecules against the antikathode lasts only for an extremely short time, a very small fraction of the period of a light-wave, so that the pulsation-wave may be considered extremely thin, there will be no sensible propagation in any direction other than the normal, and therefore there will be no diffraction. (The differences—penetrating power, absorbability—between Röntgen rays from different sources would be explained by differences between the times during which the perturbation continues and corresponding differences between the thicknesses of the part of the ether disturbed by the passing wave. When the vacuum is very high, the molecules probably reach the antikathode with higher velocities and the resultant perturbation is more abrupt: then the penetrating power of the wave is greater.) The same explanation accounts for the sharpness of the shadows: periodicity of the perturbations is not necessary. II. *The absence of refraction*, or rather its immeasurable smallness. This has led the author to a new theory of refraction. Give up the idea that refraction occurs *immediately* on light entering a prism; assume the relation between molecules of ether and molecules of ordinary matter to be like that between a string and a massive sounding-board: then the etheric vibrations are hampered in their course by passing among the molecules which they tend to set in motion. Some time will pass before the molecules are set fully in motion; and according to the period and the direction in which the molecules are successively set in vibration, there will be some mode of movement which the system

spontaneously tends to take up, and all other movements will tend to die away continuously while the former will be maintained. After say 100,000 vibrations (=say 1/40,000,000,000 second), the molecules of the glass will all be vibrating harmonically with those of the ether. In the Röntgen rays considered as consisting of independent pulsations, there would be no chance of this kind of harmony being established. In the case of light, the kinetic energy would be partly in the ether, partly in the matter; and for each period, each wave-length, the energy should be the same in the glass and in the air outside the glass; but this cannot be unless the wave-length is shorter in the glass. In a transparent substance a permanent condition is reached; in an opaque one it is not, but the movements of the molecules are continuously being handed on to other molecules: these differences are not such as to make any difference to Röntgen rays.—Becquerel's rays stand between light and Röntgen rays. These rays, from metallic uranium, traverse black paper so as to affect a photographic plate; and they can discharge a static charge. The molecule of uranium has seemingly a constitution like that of a flexible chain supporting a small weight: vibrations communicated to the top become far from true harmonic ere reaching the small weight. This gives the idea of perturbations neither successively single like Röntgen rays, nor truly harmonic like light, but partaking of the nature of both, irregular enough to go through black paper and regular enough to be refracted. These rays can be polarised.

[For French translation, with mathematical proofs, see *Ecl. Électr.* 14. pp. 374–387, 1898.] A.D.

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913. *Evidence that Röntgen Rays are Ordinary Light.* **G. J. Stoney.** (Phil. Mag. 45. pp. 532–536, and 46. pp. 253–254, 1898.)—This enquiry is based upon Sir George Stokes's explanation of Röntgen rays, which amounts to this,—That kathode rays consist of negatively charged missiles, shot in showers like hedge-firing from the negative electrode against a target which receives and suddenly arrests them; and that the Röntgen rays are due to the independent pulses propagated through the ether when the advances of their negative charges are thus abruptly stopped or altered. According to this view, the radiation from the target reaches the object which is being skiagraphed as an undulation consisting of irregular pulses. The present inquiry is as to what part of this irregular undulation can pass through the object and arrive at the fluorescent screen beyond. This is ascertained by showing that the undulation of irregular pulses can be resolved into trains of waves of different wave-lengths, among which waves of short wave-length are abundant if the hedge-firing have been sufficiently violent and irregular. The resolution is effected by combining MacCullagh's method of analysis with Fourier's in such a way as secures that the resolution is a physical one, and not merely kinematical. The radiation which traverses

the space between the target and the object becomes thus the same physical event as the coexistence in that space of the trains of waves of various wave-lengths indicated by this method, which are such that each train has an actual physical existence and advances through the ether independently of the rest. All these constituent trains encounter the object, which is of such a kind that it is opaque to those of longer wave-length, while it allows those of short wave-length to pass on and reach the fluorescent screen. These, accordingly, are what produce the Röntgen effect. The more violent, abrupt, and irregular the hedge-firing, the more abundant will these essential constituents of short wave-length be.

AUTHOR.

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914. *Distortion in Sciagraphy.* **O. L. Schmidt** and **W. C. Fuchs.** (West. Electn. 22. p. 180, 1898.)—With a focus-tube 11 inches long, 4 in. in diameter, and 6 in. between electrodes, if F be the distance of a point in the object from the focus line of the tube, P the distance of that point from the sensitive plate, then the distortion D in the image of that point is, when the distance between the tube and the plate is 50 cm., equal to (0·022433 FP) cm.

A. D.

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915. *Crypto-luminescence of Metals under Röntgen Rays.* **A. Rôiti.** (Roma, R. Accad. Lincei, Atti, 7. pp. 87–91, 1898.)—Certain metals appear to have different permeabilities to Röntgen rays according to their distance from the vacuum-tube. This is due to a transformation into "crypto-luminescent" rays, which are more readily absorbed by air than the Röntgen rays which give rise to them.

A. D.

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916. *Diffusion of Röntgen Rays.* **R. Malagoli** and **C. Bonacini.** (Roma, R. Accad. Lincei, Atti, 7. pp. 96–104, 203–210, 1898.)—Experiments tending to show that the influence of the intervening air as a diffusive reflector is extremely small, and that the apparent bending of Röntgen rays is due to the action of surrounding bodies mainly, these surrounding bodies acting as diffusive reflectors, and doing so equally well in powder or as solids. Substances of greater specific weight transform the character of Röntgen rays incident upon them: substances of small specific weight act simply as diffuse reflectors: while those of intermediate specific weight produce intermediate results. Mercury is the only liquid which has the former of these effects.

A. D.

HEAT.

917. *Fusing-Points of Silver and Gold.* **D. Berthelot.** (Comptes Rendus, 126. pp. 473–476, 1898.)—A platinum-platino-iridium thermocouple is mounted in the neighbourhood of a platinum circuit with a silver or gold wire inserted in it. At fusion of the wire the current is broken. The temperatures indicated by the thermocouple are 962° for silver and 1064° for gold. The majority of previous determinations also give a difference of 102° between the two fusing-points. E. E. F.

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918. *Fusing-Point of Aluminium-Antimony Alloy.* **E. van Aubel.** (Journ. de Phys. 7. pp. 223–224, 1898.)—Referring to the results obtained by Roberts-Austen and C. R. A. Wright in their experiments on the fusing-point of alloys and the anomalies of gold-aluminium and aluminium-antimony when alloyed, the author repeats the experiments on the formation of an alloy corresponding to AlSb, which Wright found did not solidify below 1000° C., this being very remarkable, since aluminium melts at 600° and antimony at 440°. M. Heraeus of Hanau prepared this alloy with specially pure metals sent to him by the author, and the point of fusion was determined by means of the thermoelectric pyrometer of Le Chatelier, which was standardised at the Physico-technical Institute of the German Empire. The two metals are melted in a crucible of graphite containing fused chloride of sodium to preserve them from oxidation. The product obtained after cooling presents two surfaces whose aspect is very homogeneous. The measurements of the fusing-point give 1078° to 1080° C. Different portions of the same mass were taken, in order to insure homogeneity of the alloy by the constancy of the point of fusion. J. J. S.

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919. *Laws of Perfect Gases.* **G. Bakker.** (Journ. de Physique, 7. pp. 152–154, 1898.)—Any one of the laws of Boyle, Charles, and Joule may be deduced with the help of thermodynamics from the other two. Two proofs are given; the simpler is as follows:—

If $f(p, v, \mathrm{T})=0$ is the equation of condition of a gas,

$$\left(\frac{\partial p}{\partial \mathrm{T}}\right)_v \cdot \left(\frac{\partial \mathrm{T}}{\partial v}\right)_p \cdot \left(\frac{\partial v}{\partial p}\right)_\mathrm{T} = -1$$

or

$$\frac{\mathrm{T}}{p}\left(\frac{\partial p}{\partial \mathrm{T}}\right)_v \cdot \frac{v}{\mathrm{T}}\left(\frac{\partial \mathrm{T}}{\partial v}\right)_p \cdot \frac{p}{v}\left(\frac{\partial v}{\partial p}\right)_\mathrm{T} = -1.$$

Boyle's law, in the form $pv=f_1(\mathrm{T})$, gives

$$\frac{p}{v}\left(\frac{\partial v}{\partial p}\right)_{\mathrm{T}} = -1.$$

Charles' law $\big(v=\mathrm{T}\phi(p)\big)$ gives

$$\frac{\mathrm{T}}{v}\left(\frac{\partial v}{\partial \mathrm{T}}\right)_v = -1.$$

Joule's law, $\epsilon=f_2(\mathrm{T})$, gives

$$\left(\frac{\partial \epsilon}{\partial v}\right)_{\mathrm{T}} = 0.$$

But

$$\left(\frac{\partial \epsilon}{\partial v}\right)_{\mathrm{T}} = \mathrm{T}\left(\frac{\partial p}{\partial \mathrm{T}}\right) - p.$$

Therefore

$$\frac{\mathrm{T}}{p}\left(\frac{\partial p}{\partial \mathrm{T}}\right)_v = 1.$$

T. E.

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920. *Isothermals of Ether.* **J. Rose-Innes.** (Phil. Mag. 45. pp. 102–106, 1898.)—This paper attempts to deal with the experimental material acquired by Ramsay and Young in their study of ether (Phil. Trans. vol. 178. A. pp. 57–93, and Phil. Mag. vol. 23. pp. 435–458). The conclusions arrived at are as follows:—

(1) If we denote the internal pressure by a, there is an extremely rapid change in the slope of $\frac{1}{av^2}$ when plotted against $v^{-\frac{1}{3}}$, in the neighbourhood of vol. 3·3. This is shown by means of a diagram.

(2) The temperature for which the pressure is accurately given by the laws of a perfect gas at a given volume remains practically constant until the neighbourhood of the critical volume is approached.

Similar conclusions had already been arrived at for isopentane. These conclusions are embodied in a formula giving the pressure in terms of the temperature and volume, and a comparison between calculation and experiment is then instituted. AUTHOR.

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921. *Latent Heat of Evaporation.* **Louguinine.** (Annal. Chim. Phys. 13. pp. 289–377, 1898.)—The chief theoretical interest in the paper lies in the examination of Trouton's Law, which states that ML/T is a constant, where M is the molecular weight of the substance, L the latent heat of evaporation, and T the boiling-point measured on the absolute scale. The determination of the latent heat by the method adopted by the author requires a knowledge of the specific heat and the boiling-point at various pressures; and in the earlier part of the paper he deals with the obtaining of these quantities. He has studied: (1) the

GROUPS (1), (2), & (6).

Name of substance.	Ethyl Alcohol.	Propyl Alcohol.	Isopropyl Alcohol.	Butyl Alcohol.	Isobutyl Alcohol.
Limits of temp. .	77° to 19°·5	90°·1 to 21°·5	80° to 21°	114°·5 to 20°·5	108°·109 to 21°
Mean Sp. H.	0·643	0·675	0·7064	0·6888	0·7159
B.P. Centigrade...	78·2	97·2	82·04	117·02	107·53
d	0·036	0·038	0·035	0·0386	0·036
L	201·47	160·97	157·82	137·87	134·34
ML/T	26·39	26·09	26·5	26·16	26·12

GROUP (2).

Name of substance.	Methylethyl Ketone.	Diethyl Ketone.	Methylisopropyl Ketone.
Limits of temp. ...	77°·5 to 20°	98°·5 to 20°	91°·5 to 20°
Mean Sp. H.	0·5493	0·5572	0·5251
B.P. Centigrade......	78·6	101·08	92·40
d	0·056	0·046	0·046
L	103·77	90·90	89·87
ML/T	21·25	20·90	21·15

GROUP (3).

Name of substance.	Diethyl-oxalic Ester.	Diethyl-carbonic Ester.	Dimethyl-carbonic Ester.	Acetal.
Limits of temp. .	185° to 23°·8	123° to 20°·2	88° to 19°·8	99° to 19°
Mean Sp. H.	0·4752	0·4745	0·4521	0·5198
B.P. Centigrade...	185·19	125·74	89·7	102·91
d	0·051	0·048	0·043	0·046
L	68·77	73·07	88·26	66·2
ML/T	21·91	21·62	21·85	20·78

GROUPS (1), (2), & (6).

Amyl Alcohol. *	Tertiary Amyl Alcohol.	Active Amyl Alcohol.	Allyl Alcohol.	Glycol.	Benzyl Alcohol.
129°·9 to 21° 0·6955	98°·5 to 20° 0·7534	125°·128 to 21°·5 0·7115	95°·5 to 20°·5 0·6654	188° to 22° 0·6621	200° to 22° 0·5402
130·11	101·81	......	96·69	197·37	205·35
0·0399	0·039	......	0·037	0·048	0·056
115·91	106·08	113·66	163·29	194·49	101·44
25·30	24·91	24·88	25·63	25·64	22·90

* By fermentation.

GROUP (2).

Methylbutyl Ketone.	Dipropyl Ketone.	Methylexyl Ketone.	Benzoic Aldehyde.
126°·5 to 21° 0·5528	140° to 20°·5 0·5520	168° to 21°·7 0·5523	172° to 22° 0·4281
127·37	143·52	172·92	178·9
0·049	0·048	0·052	0·055
82·35	75·73	74·17	89·23
20·57	20·73	21·29	20·93

GROUP (4).

Name of substance ...	Octane.	Decane.	Benzene.
Limits of temp. ...... Mean Sp. H.	123° to 20°·5 0·5792	154° to 21°·5 0·5899	77°·2 to 19°·3 0·4349
B.P. Centigrade	125·30	159·66	80·20
d	0·048	0·046	0·043
L	70·84	60·06	92·97
ML/T	20·28	19·7	20·53

saturated alcohols of the fatty series, as well as unsaturated allyl alcohol; (2) the ketones of the fatty series and the oxide of mesityl, which can be regarded as an unsaturated ketone; also benzoic aldehyde; (3) the neutral esters of the dibasic acids, carbonic and oxalic, as well as acetal; (4) octane, decane, and benzene; (5) ethylene glycol; (6) benzene.

Some of the results are given on pp. 482–3, where T indicates the boiling-point under standard conditions, and d the variation of the boiling-point for a change of 1 mm. of mercury in the pressure. The author observes that the values of ML/T not only vary from one group of chemical substances to another, but also, although to a much smaller extent, within the limits of the same group; nevertheless, these variations are not so great that they prevent the calculation of the latent heat of evaporation of the substances composing a group. A. Gs.

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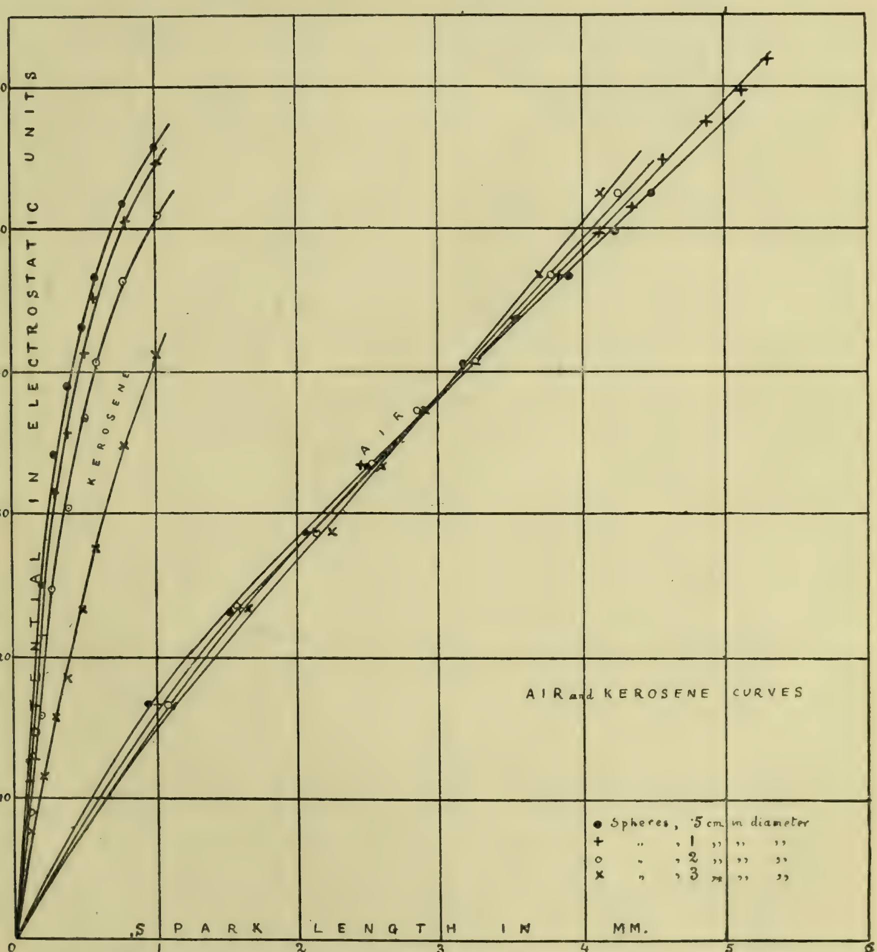
922. *Liquid Air*. (Eng. News, 39. pp. 245–247, 1898.)—A brief account is given of the apparatus devised by **C. E. Tripler** for liquefying air. An air-compressor rated at 60 H.P. is used, driven by steam, and consisting of three water-cooled cylinders in tandem, in addition to the steam-cylinder. Atmospheric air is drawn through a dust-separator and raised in three stages to a pressure of 2200 lbs. per sq. in. The air is then passed through cooling tanks and drying apparatus to the "liquefier," which is not described in detail, but of which the action is as follows:—Air entering at the upper end of the liquefier under a pressure of 2200 lbs. per sq. in. passes downwards through coiled pipes to the lower end, where it escapes through reducing-valves; the sudden expansion cools the air, which, in rising amongst the pipes to an outlet at the top, further cools the in-coming air within the pipes. The cooling action is therefore cumulative, so that after the apparatus has been at work about 20 minutes the temperature is reduced below $-220°$ F. and liquid air begins to collect at the bottom of the liquefier; from thence it may be drawn off through a valve. An output of 3 or 4 gallons per hour is said to be attained with ease.

A comparison is drawn between this apparatus and those of Linde (Abstract No. 774) and Hampson; and it is stated that the probable cost of production is about $7\frac{1}{4}d.$ per gallon, exclusive of interest on capital etc. On allowing 95 % of the liquid to evaporate, the residue contains 90 % of the oxygen originally present, in the proportions of 88 parts oxygen to 12 parts nitrogen. The liquid may be transported by rail, in well-lagged open vessels, without difficulty. Various uses have been suggested for the product, chief of which are refrigeration and blasting. Several interesting phenomena and experiments with liquid air are briefly described. A. H. A.

ELECTRICITY.

923. *Spark Discharge in Air and Liquid Dielectrics.* **T. W. Edmondson.** (Phys. Rev. 6. pp. 65–97, 1898).—For measuring the sparking potential difference between the two electrodes, the author uses an attracted-disc electrometer. The disc (which is provided with a guard-ring) is suspended from one arm of a balance, a portion of the suspension consisting of a quartz fibre. The other arm is loaded with any desired weight (depending on the potential difference which it is desired to obtain), the



beam being checked so that the pointer is at the first scale-division to the right of the zero. The electrometer and spark-gap being connected in parallel with each other and with a leyden, the handle of a Wimshurst machine which supplies the potential difference is turned as uniformly as possible, while the distance between the electrodes is adjusted by means of a micrometer until, at the passage of a spark, the pointer of the balance just moves to the left. Spherical electrodes were used in every case, and the dielectrics experimented on comprise air and a large number of the insulating oils. The results for air and kerosene are plotted in the accompanying curves. The air-curves show clearly that, while a smaller difference of potential is necessary to produce a discharge through a given distance for large spheres than for small ones when the spheres are *close together*, for greater distances the dielectric is electrically stronger for the large than for the small spheres. Whether the same results hold for the insulating oils the present experiments do not show, as it was impossible to obtain consistent readings for spark-lengths of more than 1·4 mm., on account of the great disturbance of the liquid due to convection-currents. When experimenting with the oils it was found impossible to obtain satisfactory results with the electrometer; the number of sparks which had to be passed before a satisfactory throw of the balance was obtained being so great, that the electrodes became coated with carbon and a chain of carbon particles was formed between them. Hence the electrometer was replaced by two spherical electrodes (1 cm. diam.), the distance between which was gradually increased until the spark preferred to pass through the oil, the potential difference being deduced from the known results for spherical electrodes in air. Results obtained with an alternating discharge (from an induction-coil) are also given; these, however, are somewhat erratic. A. H.

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924. *Retardation of Point Discharges.* **K. Wesendonck.** (Annal. Phys. Chem. 65. 1. pp. 116–122, 1898.)—The fact that negative discharge-potentials in hydrogen are higher than the positive ones has been attributed to a retardation; and it has been suggested that the maintenance for some time of the needle at a lower difference of potential might lead to a better value. After every precaution is taken, the average negative potentials are slightly less than the average positive ones, the former varying between −1350 and −1500 volts, and the latter between 1450 and 1500. The deposition on the needle of an invisible amount of mercury is capable of increasing the negative discharge-potential to 2000 volts. E. E. F.

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925. *Static and Dynamic Spark-Potentials.* **R. Swyngedauw.** (Journ. de Physique, 6. pp. 465–472, 1897.)—The frequency of the sparks, the state of polish of the electrodes, the presence of ultra-violet light, and the influence of X-rays affect in a different

manner the difference of potential necessary for a slow (static) discharge and for a sudden (dynamic) discharge. In the usual arrangements for determining the critical distance, the dynamic spark-potential is generally different from the static spark-potential. According to the accidents of the experiment, it is larger or smaller or equal to it, and the difference can attain a notable fraction of the spark-potential. But with suitable precautions, designed to eliminate the disturbances mentioned, the two discharge-potentials may be shown to be equal in every case. E. E. F.

926. *Arc Prevention by Subdivided Break.* **A. J. Wurts.** (Elect. World, 31. p. 498, 1898.)—The article deals with the *modus operandi* of a multiple-break switch, the breaks being arranged in series so as to subdivide the arc. It has been stated by some writers that the arc is extinguished by the cooling effect of the electrodes. The author denies this, pointing out that when once an arc is established between two metallic surfaces, any conduction of heat which may subsequently take place is not found to appreciably affect the arc. He maintains that the action of a subdivided break is nothing more than the gradual introduction of the resistance and counter-E.M.F. of the individual arcs formed in succession as the circuit is opened. A. H.

927. *Dispersion of Kathode Rays.* **J. R. von Geitler.** (Annal. Phys. Chem. 65. 1. pp. 123–140, 1898.)—A flat kathode is placed at one end of a long vacuum-tube, and a wire kathode near the other end. The anode is in a side-tube between the two. When the two kathodes are joined by a wire, and the tube is excited by means of an induction-coil, the shadow of the wire appears broadened out, owing to electrostatic deflection. On inserting a condenser between the two kathodes, fringes appear on the walls of the tube, ranging in number from two to seven, the number being increased by increasing the capacity of the condenser or the pressure of the gas. The fringes are not due to interference, but to the fact that the condenser sends out successive trains of rays of decreasing intensity, each of which is deflected more than the previous one. A similar effect may be produced by magnetic deflection, the tube being half filled up by a semicircular metallic screen. E. E. F.

928. *Ortho-kathodic Rays.* **A. Sandrucci.** (Roma, R. Accad. Lincei, Atti, 7, pp. 104–108, 1898.)—Both electrodes give off ortho-kathodic rays, the kathode more powerfully: in two cones of radiation (under a certain exhaustion) similarly affected by the magnet. The violet light of the anode reacts to the magnet as if it were a rectilinear electric current passing *from* the anode to the anti-anode. A. D.

929. *Deflection of Canal Rays.* **W. Wien.** (Berlin. Phys. Gesell. Verh. 17. pp. 10–12, 1898.)—A hole 2 mm. in diameter is bored in a metal plate, and glass tubes are cemented on to it on both sides. Into one of the glass tubes an anode is inserted, while the other carries two electrodes producing an electrostatic field. At a proper exhaustion, a bundle of canal-rays emerges from the hole, producing a fluorescent patch of the well-known yellow-brown colour on the wall of the tube. A difference of potential of 2000 volts, produced by a high-potential accumulator, produces a deflection of 6 mm. towards the negative electrode. For producing magnetic deflection, the magnetic influence of the induction-coil on the kathode rays must be shielded off by enclosing the anode tube in an iron cylinder. Then the canal-rays are clearly deflected, to the extent of 6 mm. for a field of 3250. The velocity of the canal-rays is calculated at $3{\cdot}6 \times 10^7$, and the ratio of the mass to the charge at $3{\cdot}3 \times 10^{-3}$. E. E. F.

930. *Specific Inductive Capacity of Oils.* **A. L. Clark.** (Phys. Rev. 6. pp. 120–125, 1898.)—By Quincke's bubble method the author finds that for ordinary kerosene the specific inductive capacity equals 2·22; for water white 150°, 2·23; export distillate, 2·06; xylol, 2·34; benzol, 2·38; paraffin oil, 2·71; white castor oil, 4·92; neatsfoot oil, 3·22; cottonseed oil, 3·88; sweet neutral oil, 2·36; high gravity oil, 2·12; olive oil, 3·52. A. Gs.

931. *Electric Resistance of Cobalt, Iron, and Nickel in Magnetic Fields.* **J. C. Beattie.** (Phil. Mag. 45. pp. 243–253, 1898.)—The films are deposited on platinised glass by electrolysis. The resistance of cobalt increases with increase of field, initially the variation being directly as the square of the strength of the field. Roughly, the Hall-effect varies as the square root of the increase in the resistance. The behaviour of nickel is different with different specimens, and even with the same specimen at different times. "In all the mirrors, however, the variation of resistance shows signs of attaining a maximum, but at a higher field than that required for the Hall-effect maximum." With iron films the variation of resistance is so small as to be difficult to measure. Its variation is probably less than proportionality to field squared would lead us to expect. A. Gs.

932. *Insulation-Test for Cable-Joints.* **E. Raymond-Barker.** (Elect. Rev. 42. p. 610, 1898.)—The author applies the principle of the "method of mixtures" to ascertain the resistance of a joint in gutta-percha or other core. Electrical connections are arranged as in the "Thomson" capacity test, the two ratio-resistances being replaced by two short lengths of core submerged in water. One of these lengths contains the joint to be tested, the other is a piece of similar core of equal length without a joint. Two standard

mica condensers, each of 1 mfd., are used for the capacity-ratios. The quantity of electricity that leaks into either condenser in a given time, say one minute, depends upon the dielectric resistance of the corresponding piece of core. If the joint on that side is faulty, the defect shows itself when the galvanometer key is depressed. This test has all the advantages of a *null* method; it requires only the ordinary apparatus of core-testing, and it appears to be more expeditious than previous joint tests. R. A.

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933. *Conductivity of Electrolytes for Small E.M.F.'s.* **H. Danneel.** (Zeitschr. Elektrochem. 4. pp. 211–213, 227–232, 1897.)—An E.M.F. insufficient to decompose continuously an electrolyte gives rise to a small continuous current through it. In the case of dilute sulphuric acid, Helmholtz explained this by the depolarising action of the hydrogen and oxygen dissolved in the liquid. The author calculates the magnitude of the current in this case when the stationary condition is attained. If, for example, the solution is saturated with hydrogen under a given pressure, the passage of the current between the platinum electrodes increases the concentration of the hydrogen at the kathode and diminishes it at the anode (owing to the action of the oxygen evolved there). Hydrogen then diffuses from the kathode to the anode, and a stationary condition is attained when the quantity of hydrogen liberated at the kathode just balances the loss by diffusion. The rate of diffusion is calculated by Fick's equation, and the fall of concentration between the electrodes corresponding to a given E.M.F. applied to them by Nernst's theory. The combination of these two equations gives an equation from which the value of the steady current which is obtained when the distribution of the dissolved gas between the electrodes has become constant may be calculated. From this equation it follows that the current should be proportional to the pressure of the gas with which the solution is saturated, and that it increases with the applied E.M.F. at first rapidly, afterwards slowly. Experiments with platinised platinum electrodes and dilute sulphuric acid saturated with hydrogen, gave values for the current about three times those calculated when the electrodes were 0·1 or 0·73 cm. apart; when they were 26 cms. apart the current diminished slowly, but after 4 days was still about 50 times the calculated value. Similar results were obtained with oxygen. The current decreases when the pressure of the gas is diminished, but more slowly than the latter. When the concentration of the depolarising nonconducting substance is large, the electrolyte behaves much in the same way as a metallic conductor. This was proved experimentally with a solution of iodine in potassium iodide. T. E.

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934. *Thomson and Varley Slides.* **A. Tobler.** (Journ. Télégraph. 22. pp. 4–9, 1898.)—This is a very complete account of the development of the Thomson and Varley slide-bridge, compiled from various sources, to which references are given. R. A.

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935. *Electrical Alloys.* **R. Appleyard.** (Elect. Rev. 42. pp. 607–610, 1898.)—This is a continuation of the article referred to in Abstract No. 806. It describes the Reichsanstalt experiments on copper, nickel, and other metals; and the effect of the quantity of nickel upon the temperature coefficients. The results are presented graphically by curves, giving the temperature-coefficient, the specific resistance, the thermoelectric force (against copper), and the chemical constitution of twelve different specimens. In the discussion of results it appears that there are two alloys of this class, both of which have vanishing temperature coefficients. These two alloys are "manganin" and "constantan." Important as is the production of an alloy possessed of a vanishing temperature-coefficient, such an alloy cannot be adopted for standard coils until the permanence of the specific resistance has been established. This being done, preference has next to be given to the alloys of least thermoelectric power (against copper). From a table of figures accompanying the curves, it is seen that manganese-copper has only small negative values of thermoelectric power (against copper); this can be got rid of by adding a trace of nickel. But nickel-copper, and especially constantan, has high thermoelectric power (against copper), and is unsuitable for coils intended for measurements of precision. Manganin would thus appear to be better for all purposes than constantan, but unfortunately manganin is rather easily oxidised. At 100° C. the wire soon tarnishes; during annealing, the surface manganese is perceptibly oxidised out of the alloy, leaving a skin of copper beneath the oxide. The electrical qualities suffer in consequence. Wire-drawers have now learnt how to drawn manganin cold, even to fine gauges. Shellac-varnish is very effective protection. Constantan, on the other hand, resists oxidation. It can be heated with impunity up to 300° C. The article concludes with some details as to the soldering of these wires. AUTHOR.

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936. *Condensers for Induction Coils.* **P. Dubois.** (Annal. Phys. Chem. 65. 1. pp. 86–91, 1898).—As already pointed out by Walter, the utility of a condenser in increasing the E.M.F. in an induction-coil ceases when the capacity of the condenser surpasses a certain value. The author determines the most useful capacities for secondary circuits of various resistances. These capacities vary from 3 microfarads for 225 ohms to 0·2 microfarad for 5225 ohms in the secondary circuit. The insertion of 10 microfarads stops all physiological action of the secondary current. The author's measurements were carried out with an electrodynamometer.

E. E. F.

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937. *Induction Coils.* **H. Armagnat.** (Écl. Électr. 15. pp. 52–62, 1898.)—This paper gives a full discussion of the theory of induction-coils, including equations and curves. C. K. F.

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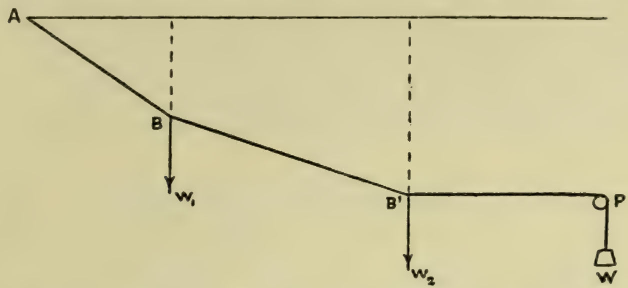
938. *Mechanical Calculator of Fall of Potential.* **W. H. Browne.** (Elect. World, 31. pp. 610–612, 1898).—The device is illustrated in the accompanying diagram. One end of a cord is



fixed at A, while the other passes over a pulley and carries a weight W. The pulley P is movable in a vertical direction (being attached to rollers running on guides). Attached to various points B, B′ in the cord are weights W_1, W_2. The position of P is adjusted until the last section B′P of the cord is horizontal. A represents the feeding-point of a distributor. Abscissæ measured horizontally to the right of A correspond to distances along the main; the weights W_1, W_2 represent currents tapped off at the corresponding points, while the ordinates of these points (measured vertically downwards) represent the fall of potential from the feeding-point. The tension W of the cord corresponds to the sectional area of the main. By affixing a properly divided scale to the board on which the apparatus is mounted, the arrangement may be made direct-reading. It is obvious that various problems on the fall of potential along a distributor may be readily solved by means of this apparatus. A. H.

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939. *Temperature Variations of Clark Cells.* **F. S. Spiers, F. Twyman,** and **W. L. Waters.** (Phil. Mag. 45. pp. 285–298, 1898.)—Similar experiments on the Board of Trade form of Clark cell were described by Prof. Ayrton and Mr. W. R. Cooper in the Proc. Roy. Soc. Dec. 1895. This paper is a completion of their work. The cells, which were of the Kahle type, were subjected to cycles of temperature, and from the resulting temperature-E.M.F. curves the required lag of E.M.F. behind temperature was determined. A suitable thermostat which kept the temperature of the standard cell constant to 0°·01 C., and a specially designed heating and cooling bath, in which the temperature was uniform to 0°·02 C. for the cells under test, are fully described. The E.M.F.s of the standard cell and that being tested were compared by a convenient and very sensitive modification of the potentiometer method. The standard E.M.F. was measured absolutely, correct to 0·0001 volt. At a rate of change of

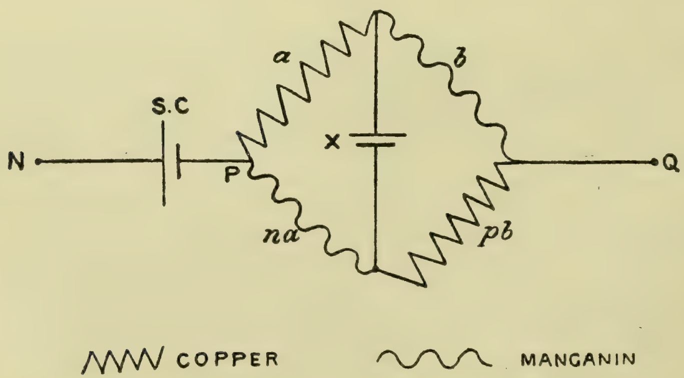
temperature of 1° C. in 7 mins., the lag of E.M.F. was 4 ten-thousandths of a volt, at 1° in 15 mins. it was $2\frac{1}{2}$ ten-thousandths, and at 1° in 30 mins. 1 twenty-thousandth. These lags are less than a quarter of those in the Board of Trade form. Experiments on the internal temperatures of the cells showed that about a half the above lags was due to temperature lag, and the rest to "diffusion" lag. Two Muirhead cells were also tested; they were somewhat inferior to the H-form as regards lag. The relative values of various types of Clark cells are discussed. Specimen curves are given. AUTHORS.

940. *Permanency of Clark Cells.* **W. R. Cooper.** (Electrician, 40. p. 748, 1898.)—The author gives the result of tests extending over $3\frac{1}{2}$ years. Cells set up in accordance with the Board of Trade specification were initially accurate to one part in 7000, but at the end of $3\frac{1}{2}$ years they showed a mean error of one in 700. Some cells showed a mean error of one in 500 after $2\frac{3}{4}$ years, the results in all cases being low. AUTHOR.

941. *Standard Cells.* **D. McIntosh.** (Journ. Phys. Chem. 2. pp. 185–193, 1898.)—The author has studied a number of cells in order to test their suitability as standards. Some good results were obtained, but no figures are given as to permanency. The cells include the Gouy cell, the $Zn—ZnCl_2—Hg_2Cl_2—Hg$ cell, the $Zn—ZnCl_2—PbCl_2—Pb$ cell, various cells having HgO as depolariser, the $Cu—CuSO_4—Hg_2SO_4—Hg$ cell, and the $Pb—PbCl_2—HgCl_2—Hg$ cell. The last but one gave good results. W. R. C.

942. *Temperature Compensators for Standard Cells.* **A. Campbell.** (Phil. Mag. 45. pp. 274–276, 1898.)—A description is

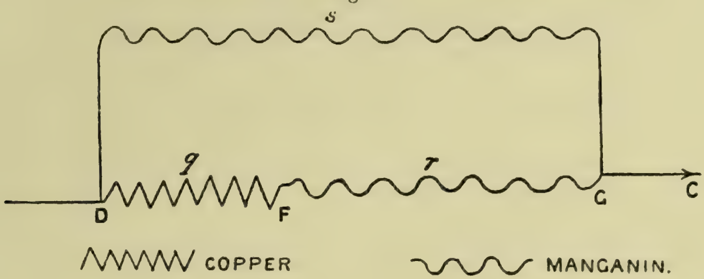
Fig. 1.



given of two pieces of apparatus for applying the temperature correction to standard cells. The theory has already been given

('Electrician,' pp. 601–603, September 1895). In the first arrangement the compensator adds or subtracts the proper small voltage in the manner shown in fig. 1. S.C. is the Clark cell, and X a Leclanché cell. The resistances a, na, b, nb had the values 48·66, 482·7, 63·63, and 495·0 ohms respectively. The whole combination when tested at various temperatures was found to give 1·400 volts to an accuracy of 1 in 2000. The second arrangement is shown in fig, 2, in which $r=s=2q=3·6335$ ohms. When

Fig. 2.



the current C is exactly 1·000 ampere, a Clark cell at any ordinary temperature will balance the voltage from F to G: thus a standard of current is obtained. AUTHOR.

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943. *Cadmium Cells.* **W. Jaeger.** (Ann. Phys. Chem. 65. 1. pp. 106–110, 1898.)—The E.M.F. of one cadmium amalgam with respect to another varies very slightly with the concentration as long as the percentage of cadmium is kept below 15. Above that value, not only does the variation in E.M.F. attain several millivolts, but it takes several days to settle down to its final value. The E.M.F. of pure cadmium with respect to a 14·3 per cent. amalgam is 0·051 volt, whereas that of zinc with respect to zinc amalgam is negligible. This constitutes an advantage of the Clark cell over the cadmium cell. But as long as the cadmium amalgam used contains under 10 per cent. of cadmium, the errors likely to be introduced are not serious. E. E. F.

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944. *Thomson Effect in a Binary Electrolyte.* **F. G. Donnan.** (Phil. Mag. 45. pp. 529–532, 1898.)—The *Ludwig-Soret* phenomenon, *i. e.* the production of concentration-changes in an unequally heated solution, has been explained by van't Hoff as due to differences of osmotic pressure. In the present paper a formula is obtained, on the basis of this theory, for the Thomson coefficient σ. The result is

$$\sigma=\frac{R}{\omega\epsilon}(1-2n)\left(1+\frac{t}{a}\frac{da}{dt}\right),$$

where R=gas-constant, ω=valency, ϵ=quantity of electricity

associated with a monovalent gram-ion, and α=degree of electrolytic dissociation. It is shown from this that the *Thomson Effect* in aqueous salt-solutions would not usually amount to more than a few thousandths of a volt at most. AUTHOR.

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945. *Hall Effect in Liquids.* **F. Chiavassa.** (L'Elettricista, 6. p. 10, 1897.)—The author repeated as nearly as he could Bergard's experiments, which were alleged to have established the presence of a true Hall effect on liquids. He obtained indications of a cross-current, but attributes it to differences of temperature and concentration, due to the want of uniformity of the magnetic field. A small liquid film exposed in a uniform field gives no indications of a Hall effect. E. E. F.

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946. *Oscillatory Currents.* **E. F. Northrup.** (Elect. World, 31. pp. 524–526, 584–585, & 607–610, 1898.)—This is a series of articles dealing with the phenomena of high-frequency currents. The writer begins by giving a simple non-mathematical account of the way in which a combination of an inductance and a capacity may be made to produce rapidly oscillating currents. Then follows a detailed account of the various methods of arranging a circuit for the production of high-frequency currents when the source of E.M.F. is an influence machine, an induction-coil, a continuous-current dynamo, or an alternator. Full directions are next given, with dimensional drawings, for the construction of a high-potential transformer, a condenser, and a high-frequency transformer, the apparatus being suitable for X-ray work on a 104- or 52-volt circuit at a frequency of 125. A. H.

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947. *Measurement of Phase-Difference.* **H. Martienssen.** (Zeitschr. Elektrotechn. Wien, 16. pp. 93–96, 108–109, & 117–119, 1898.)—Two methods are described. In the first, a Joubert contact-maker in the circuit of a galvanometer connects it periodically across a non-inductive resistance included in each of the two circuits under test. The position of the contact-brush corresponding to zero value of the current is ascertained for each circuit, and thus the phase-difference determined. The second method involves the use of a phase-meter consisting of 3 coils. Two of these are wound side by side on the same bobbin, while the third is placed at right angles to them. In the central space is suspended a hollow sphere of pure silver. The currents are sent through two of the coils which are at right angles to each other. The circuit of the remaining or secondary coil is closed through a non-inductive resistance. The author shows that if M stand for the mutual inductance of the co-planar coils, and r for the total resistance of the secondary circuit, then, assuming r to have been adjusted until there is no deflection of the silver shell (indicating the absence of a *rotating* field), the angle of phase-difference is approximately $\phi=\tan^{-1}(p\mathrm{M}/r)$, this result being correct within $\frac{1}{2}$ per cent. so long as $p\mathrm{L}/r<\cdot03$, L being the self-inductance of the secondary

coil. By this method it is possible to measure values of ϕ up to the limit determined by the maximum value of M/r. For larger values, an auxiliary coreless induction-coil may be used, whose primary and secondary are connected respectively in series with those of the phase-meter. The new value of M must, of course, in this case be determined. Examples of measurements by both methods are given. A. H.

948. *Effects of Heating on Magnetic Properties of Iron.* **S. R. Roget.** (Roy. Soc. Proc. 63. pp. 258–267, and Electrician, 41. pp. 182–184, 1898.)—The paper contains some results of a series of experiments on the change of hysteresis in soft iron transformer-plate, due to continued heating for various different temperatures. The specimens, initially in the annealed state, were heated in small ovens, and removed periodically to be tested in Prof. Ewing's hysteresis-tester at atmospheric temperature. Below 40° C. no evidence was found of any change. Between 40° C. and 135° C. the hysteresis increased with time, at first rapidly, and slower later. At higher temperatures the value of the hysteresis reaches a maximum, and then decreases; for example, at 160° C. the hysteresis doubled in a few hours and nearly trebled in a few days, afterwards falling. Beyond about 180° C. the hysteresis, although rising more rapidly at first, does not reach so high a maximum value and begins to fall sooner and faster, tending apparently to a lower steady state the higher the temperature. For example, at 260° C. the maximum was already passed in 15 minutes, a steady state only 50 % above the original hysteresis being reached in about 15 days. In all cases the original state was restored by reannealing. Ballistic curves are also given for a ring of similar material, before and after heating. AUTHOR.

949. *Magnetic Susceptibility of Water.* **H. du Bois.** (Annal. Phys. Chem. 65. 1. pp. 38–40, 1898.)—The author points out that he had forestalled Jaeger and Meyer in indicating the temperature-coefficient of the susceptibility of pure water. As regards their discovery that the atomic magnetisms of Ni, Co, Fe, and Mn are in the ratio 2:4:5:6, his own experiments, as far as they go, tend to confirm it (see Abstract No. 161). E. E. F.

950. *Magnetic After-Effect.* **C. Fromme.** (Annal. Phys. Chem. 65. 1. pp. 41–71, 1898.)—The experiments are limited to the effect observed after a diminution of the magnetising force. When that is reduced to a value above zero, the slow change of magnetisation is termed the after-effect of the temporary moment. When the force is reduced to zero, the effect observed is called the after-effect of the permanent moment. The latter does not depend in any way upon the duration of the magnetising influence. But it decreases when the reduction to zero is accomplished very rapidly; and, conversely, it increases when the reduction is accomplished

gradually, or through several intermediate stages. Heating the wire accelerates the after-effect of the permanent moment, without affecting its value; but repeated bending diminishes it as well. This is explained on the molecular hypothesis by supposing that local tensions are broken up by heating and bending, and so allow the magnetic effects more free play. E. E. F.

951. *Magnetisation and Conductivity.* **G. Milani.** (N. Cimento, 4. 6. pp. 191–197, 1897.)—Experiments made by Neesen in 1884 indicate that magnetisation exercises a slight influence upon the electric conductivity of a solution of ferric chloride when the tube containing it is parallel to the magnetic lines of force. A series of careful experiments made by the author with strong magnetic fields show that this effect does not exist, or is too slight for detection. E. E. F.

952. *Magnetic Deformation of Nickel.* **E. T. Jones.** (Roy. Soc. Proc. 63. pp. 44–54, 1898.)—An account is given of experiments which are a continuation of those described by the author in Phil. Trans. 189. (1897) p. 189, which consisted of measurements of the magnetic contraction of a nickel wire and a comparison of these with the values deduced from Kirchhoff's theory. The observed contraction of nickel was much greater than the calculated value. From the repetition and extension of the experiments here described on the effect of temperature on the magnetic contraction, it appears that at low fields (up to 90 C.G.S.) a rise of temperature of 35° C. caused an increase, at higher fields a diminution of contraction; and if the temperature was then lowered, the contraction returned to its former value. Observations were made on change of length and corresponding field-strength. Measurements were next made of the magnetisation, and the effect of change of tension on the magnetisation. The most important term in the calculated value of the elongation of a long wire of soft magnetic metal is represented by $\frac{1}{2}H(\delta I/\delta P)$, where H is the magnetising field and δI the increase of magnetisation produced by a small increase of longitudinal tension δP per unit area. The experiments indicate a slow time-change in the magnetic behaviour of the nickel wire. The effect of this change on $\delta I/\delta P$ is very marked at low fields, though slight at higher fields; $\delta I/\delta P$ appears to diminish rapidly at low fields, as time goes on. This is remarkable, as the magnetic contraction at low fields seemed to change but slowly with time, and more rapidly at higher fields. Some of the results are shown graphically, and all are recorded in tables showing the corresponding changes in the quantities observed. J. J. S.

953. *Cycles of Magnetic Torsion.* **G. Moureau.** (Comptes Rendus, 126. pp. 463–466, 1898.)—When an iron wire is subjected to a torsional cycle, the magnetic torsion also goes through

a cycle. That torsion for which the magnetic torsion is zero is termed the residual torsion. It is the same for all magnetic fields, and offers a well-marked criterion of the magnetic properties of a substance. The residual torsion is inversely proportional to the thickness of the wire. For a diameter and length of 1 cm., this torsion is 0·00067 of the circumference. When a certain torsion is reached, the generators of the cylindrical wire are torn, and the wire does not return to its original state.

E. E. F.

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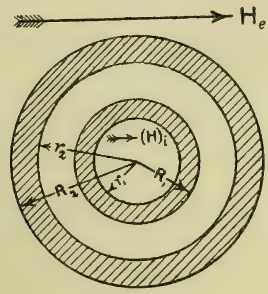
954. *Magnetic Shielding.* **H. du Bois.** (Electrician, 39. 1897, and 40. pp. 814–817, 1898.)—In this elaborate series of articles, the shielding-effect of spherical and cylindrical sheaths is fully considered. Details of calculation are in most cases omitted, the method used in arriving at certain results being merely outlined.

Theory of Spherical and Cylindrical Bi-lamellar Sheaths.—It is assumed that the sheath is of homogeneous isotropic material, and that its permeability is constant. It is placed in a uniform field of intensity $\mathbf{H}_e$, and the problem is to express the ratio (called by the author the "field-ratio") $g = \mathbf{H}_e/(\mathbf{H})_i$, where $(\mathbf{H})_i$ denotes the field inside the sheath, in terms of the permeability μ and the geometrical data of the sheath. Starting from the well-known expressions ($-\frac{4}{3}\pi\mathbf{I}$ and $-2\pi\mathbf{I}$) for the demagnetising intensities inside a solid uniformly-magnetised sphere and cylinder (axis normal to field) respectively, the author points out that similar expressions, but with sign reversed, hold for the case of spherical or cylindrical air-cavities hollowed out of an infinitely extended uniformly magnetised medium.

From these results are deduced expressions for the normal components of **B** at points on a spherical or cylindrical surface

Fig. 1.



lying either inside or outside the surface of separation of the two media. If now a bi-lamellar sheath, such as the one shown in section in fig. 1, be considered, there will be four boundaries

separating the non-magnetic from the magnetic material. Corresponding to each boundary an equation may be written down expressing the continuity of the normal induction on each side of the boundary. From these four equations, after elimination of the quantities not required, the author arrives at the following expressions for the "field-ratio" g:—

$$g-1=\frac{2}{9}\frac{(\mu-1)^2}{\mu}\left\{(1-p_1p_2)+\frac{2\mu^2+5\mu+2}{9\mu}m_{12}m_1m_2\right\}\quad . \quad \text{(I.)}$$

for a spherical bi-lamellar, and

$$g-1=\frac{1}{4}\frac{(\mu-1)^2}{\mu}\left\{(1-q_1q_2)+\frac{(\mu+1)^2}{4\mu}n_{12}n_1n_2\right\}\quad . \quad . \quad \text{(II.)}$$

for a cylindrical bi-lamellar; where (see fig. 1)

$$\begin{aligned}
p_1 &= r_1^3/R_1^3; & p_2 &= r_2^3/R_2^3; & p_{12} &= R_1^3/r_2^3;\\
m_1 &= 1-p_1; & m_2 &= 1-p_2; & m_{12} &= 1-p_{12}.\\
q_1 &= r_1^2/R_1^2; & q_2 &= r_2^2/R_2^2; & q_{12} &= R_1^2/r_2^2;\\
n_1 &= 1-q_1; & n_2 &= 1-q_2; & n_{12} &= 1-q_{12}.
\end{aligned}$$

Discussion of Theoretical Equations.—In order to compare the shielding effect due to a bi-lamellar with that of a single thick shell of the same dimensions, we may suppose that R_1 becomes equal to r_2; *i. e.*, that the interferric air-shell vanishes. We then get

$$g'-1=\frac{2}{9}\frac{(\mu-1)^2}{\mu}(1-p') \quad \text{for a spherical shell,}$$

and

$$g'-1=\frac{1}{4}\frac{(\mu-1)^2}{\mu}(1-q') \quad \text{for a cylindrical shell,}$$

where

$$p'=r_1^3/R_2^3 \quad \text{and} \quad q'=r_1^2/R_2^2.$$

From this it is at once seen that $g'<g$; an advantage is therefore secured by the use of an interferric space between the two shells. The formulæ may be simplified by supposing (1) that μ is large (>100), and (2) that the thickness d of each shell is small in comparison with its radius. The formulæ then become

$$g-1=\frac{2}{9}(\mu-2)\left\{\frac{3d_1}{R_1}+\frac{3d_2}{R_2}+2\left(\mu+\frac{5}{2}\right)m_{12}\frac{d_1}{R_1}\cdot\frac{d_2}{R_2}\right\}$$

for a thin spherical bi-lamellar, and

$$g-1=\frac{1}{4}(\mu-2)\left\{\frac{2d_1}{R_1}+\frac{2d_2}{R_2}+(\mu+2)n_{12}\frac{d_1}{R_1}\cdot\frac{d_2}{R_2}\right\}$$

for a thin cylindrical bi-lamellar.

For thin uni-lamellars, we get

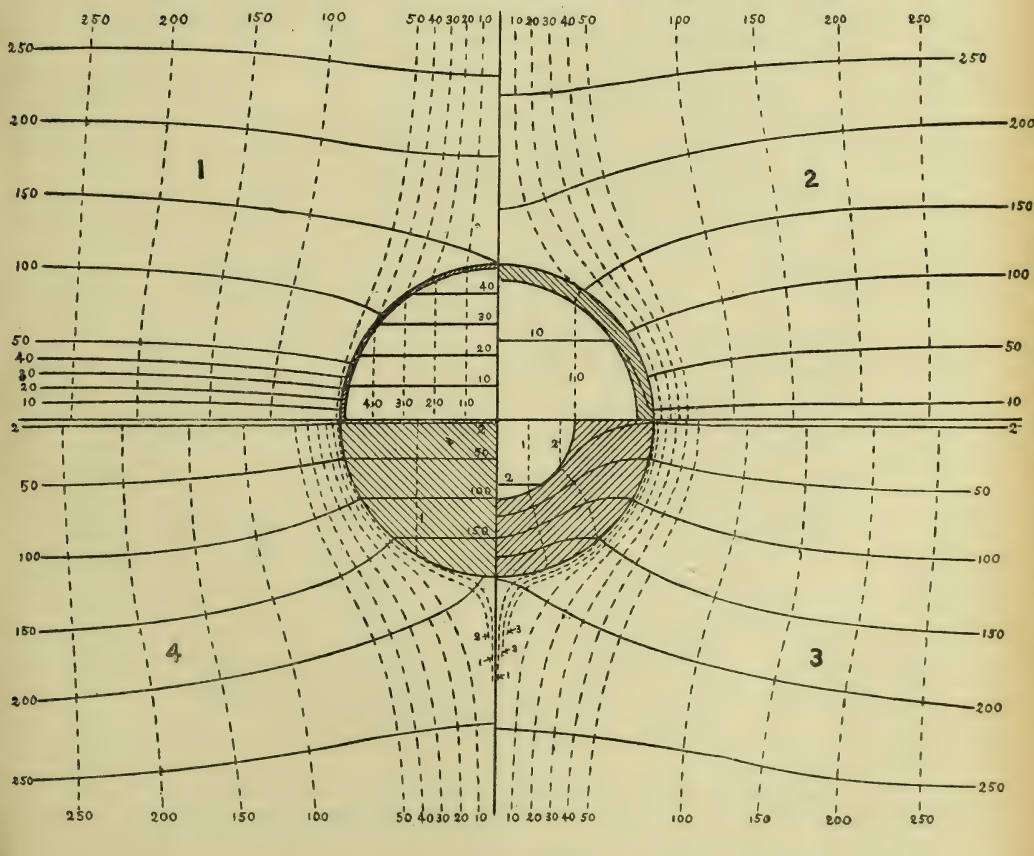
$$g-1=\frac{2}{3}\frac{d}{\mathrm{R}}(\mu-2)\doteqdot\frac{8\pi\kappa}{3}\frac{d}{\mathrm{R}}\quad\text{(sphere)},$$

and

$$g-1=\frac{1}{2}\frac{d}{\mathrm{R}}(\mu-2)\doteqdot 2\pi\kappa\frac{d}{\mathrm{R}}\quad\text{(cylinder)}.$$

Corollaries of Theoretical Equations.—The last set of equations suggests a simple method of measuring the *initial permeability* or susceptibility of iron sheet or wire. For if the value of g be determined by any suitable method, the equations enable us to find the corresponding value of μ or κ.—The relation between the shielding effect and weight of shell is next discussed. It appears that with uni-lamellars the shielding effect is, for small thicknesses of the shell, nearly proportional to the thickness ; but beyond a

Fig. 2.



certain limit (a thickness $=10\,\%$ of mean radius for spheres, and $15\,\%$ for cylinders) very little is to be gained by further increasing the thickness. Beyond this limit it is better to subdivide the shield, making it bi-lamellar. For the latter, the condition of minimum weight is approximately satisfied by making $r_2/R_1=1{\cdot}3$ to 1·4 for spheres and 1·5 to 1·6 for cylinders.

Graphical Representation.—Fig. 2 (p. 499) is a diagram showing the shielding effect in an originally uniform field due to (1) a very thin cylinder ($r/R=\cdot98$), (2) a somewhat thicker cylinder ($r/R=\cdot92$), (3) a cylinder of considerable thickness ($r/R=\cdot5$), (4) a solid cylinder. The permeability is taken as 102. The full lines are lines of magnetic induction, the dotted ones being equipotentials. It will be seen that in the case of the thin cylinder the lines enter the *outer* surface of the shell obliquely, and that as the thickness increases the angle of incidence approaches a right angle. At the *inner* surface, on account of the fact that the field inside the shell must be uniform, the lines are not in general normal to the surface. The lines are numbered, so that their course may be easily traced. An iron-filings picture confirming the theoretical diagram of fig. 2 is also given by the author.

Internal and External Shielding.—In the preceding discussion the shielding has been *internal*—*i. e.* the object of the shield has been to protect the space inside it against external disturbance; but cases may arise in which a shield is used for the protection of external space against magnetic disturbances going on within the shield. Such cases may be referred to as *external shielding.* This is not always possible; *e. g.*, in the case of a *single* magnetic pole contained within the sheath, or a linear current along its axis, no shielding effect takes place. But with a circular current, or two poles within the sheath, shielding is effective. It may be shown, by several methods, that for a given sheath the internal and external shielding ratios (g) are equal.

Experimental Investigation.—Some preliminary experiments are described in which the shielding effect was determined by the method of oscillations. This not proving satisfactory, except for rough measurements, the method of deflections was resorted to. The results obtained are in as good agreement with theory as might be expected. They also show that for moderate disturbing fields the shielding depends on the constant initial permeability for small increments or decrements of force, the actual magnetisation of the sheath not affecting the result. This is clearly shown in one case, in which the sheath was circularly magnetised by a coil of wire without the occurrence of any perceptible change in its shielding effect. Another experiment shows that when the length of a cylindrical sheath is three or four times its radius, the shielding in the central portion is practically the same as that due to the infinitely long cylinder considered in the theoretical part of the investigation.

Permeability Tests.—The formulæ developed in the earlier part of the paper are applied to the determination of the initial

permeability by means of a "shield permeameter" (which is fully illustrated and described), the method of deflections being used. Values of the initial permeability ranging from 100 to 234 are obtained by this method.

Applications of Shielding.—In most practical cases, bi-lamellar sheaths will afford sufficient protection. If three sheaths are used, it is probably best to make the thickness of each about equal, and not more than, 10 % of its mean radius, and to make the clear width of each of the two air-spaces about 30 % of its mean radius.

Dynamical Shielding.—In this section the effect of magnetic shielding on the dynamical stresses existing between the impressed field and any part of an electromagnetic system is discussed. It is shown, from the principle of the conservation of energy, that the "field-ratio" has the same value for a given shield, whether the shielding be internal or external.

Current Shielding.—The particular case of a straight axial current shielded by a concentric cylinder is considered in detail. An experiment is described which shows that with a cylindrical sheath of transformer-iron 4 cms. in diam. and only ·039 cm. thick, as much as 93 % of the dynamical force is transferred to the shield. Thicker shields would take up practically the whole of the force. Reproductions are given of filings-pictures obtained with (*a*) a straight unshielded conductor in a uniform field, (*b*) a similar conductor surrounded by a cylindrical sheath.

Induced E.M.F. in Shielded Conductors.—The fact that when a shielded conductor moves (with its shield) across a uniform field, the E.M.F. induced in it is identical with that of an unshielded conductor (although in the former case the conductor is always in a very much weaker field), is best explained by considering *tubes* of induction rather than lines of force. The velocity with which the axis of the conductor crosses the tubes must be proportional to their section if the magnetic configuration is to remain unaltered during motion. Hence the induced E.M.F. is not affected by shielding.

The paper concludes with a discussion of some filings-pictures which show very clearly how the tangential drag on a dynamo armature is produced by current-carrying conductors embedded in slots of various shapes in the core. A. H

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

955. *Determination of Molecular Weighs of Gases from their Densities.* **D. Berthelot.** (Comptes Rendus, 126. pp. 954–956, 1898.)—Since gases obey the laws of Boyle and Charles more closely as the pressure is diminished, the author assumes that at infinitely small pressures they would obey these laws exactly, and therefore all gases would have exactly the same molecular volume. Calling v the volume of a quantity of gas at infinitely small pressure p, and v_0 its volume at atmospheric pressure p_0,

$$\frac{p_0 v_0}{pv} - 1 = a(p - p_0),$$

where a is constant for moderate pressures and is assumed to remain so down to pressure p. From this equation

$$v_0 = vp/p_0(1 + ap - ap_0).$$

Taking quantities of two different gases which occupy equal volumes at infinitely small pressure (that is, by hypothesis, equal molecular quantities), we find the ratio of their volumes at atmospheric pressure to be

$$v_0/v_0' = (1 - ap_0)/(1 - a'p_0).$$

The product of the molecular volume thus found and the density is obviously proportional to the molecular weight of the gas, which is thus obtained from the density and compressibility of the gas at the ordinary temperature. The following molecular weights are calculated from the determinations of Leduc:—Hydrogen 2·01472, nitrogen 28·0132, carbonic oxide 28·0068, oxygen being taken as 32. T. E.

956. *Explosion of Mixtures of Methane and Air by Electric Spark.* **H. Couriot** and **J. Meunier.** (Comptes Rendus, 126. pp. 901–904 & 1134–1136, 1898.)—A wire may be raised to incandescence and fused in a mixture of air and methane containing 9·5 °/₀ of the latter, without causing explosion; the spark which occurs when the wire breaks produces the explosion. Using an E.M.F. of 110 volts, the spark fails to produce an explosion if a shunt is attached to the terminals of the wire passing through the explosion vessel, provided that the shunt has nearly the same resistance as the wire. When the resistance of the shunt is much larger or much smaller than that of the wire, explosion is produced by the spark. If the wire is coiled up so as to possess more or less self-induction, the spark brings about the explosion more readily; by diminishing the E.M.F. employed, however, the explosion is again prevented. T. E.

957. *Eutectic Alloys.* **G. Charpy.** (Journ. de Physique, 7. pp. 145–151, 1898.)—Alloys of tin and bismuth are examined in the way described by the author previously (Comptes Rendus, 1897, 124. pp. 957–959). Microphotographs of etched sections of the eutectic alloy and of alloys containing excess of one or other constituent are given. The analogous structure of a silver-antimony alloy and of steel is pointed out. T. E.

958. *Osmotic Pressure.* **J. Larmor.** (Cambridge Phil. Soc. Proc. 9. pp. 240–242, 1897.)—The author considers that the thermodynamic basis of the law of osmotic pressure is valid. The hypothesis of ionic dissociation must be judged separately by its agreement with the facts. The author takes the view that each molecule of a dissolved substance sensibly influences the molecules around it up to a certain minute distance, so as to form a loosely connected complex. So long as the solution is so dilute that each of these complexes is for the greater part of the time out of range of the influence of the other complexes, the principles of thermodynamics necessitate the osmotic law. This is so, whether the nucleus of the complex is a single molecule, a group of molecules, or an ion; the pressure merely depends on the number of complexes per unit volume. To determine the osmotic forces, the change of available energy involved in diluting the solution is needed. To find this, the laws of the mutual action between the molecules of the dissolved substance are not required, because there is no such action. In concentrated solutions where such action exists the theory does not hold. The laws of the mutual action between the dissolved substances and the solvent are also not required to be known, because the addition of more solvent to the solution does not in any way alter the individual complexes. The effect of dilution is merely to scatter these through a larger volume, and the change of available energy is due to this expansion in the same way as in the expansion of a gas. T. E.

959. *Electrolysis of Water.* **P. Garuti.** (Elettricità, Milan, 17. pp. 152–153, 1898.)—The chief difficulty in the preparation of hydrogen and oxygen by electrolysis of water lies in the complete separation of the gases with due regard to economy. Attempts in this direction have hitherto only been made with the aid of non-permeable diaphragms between the electrodes; but owing to the great resistance thus offered to the current, and to practical difficulties, such methods have no commercial value. The use of metallic diaphragms has been considered impossible, it being supposed that they must necessarily take part in the electrolysis, hydrogen being evolved at the face opposite the anode, and oxygen at that opposite the kathode; and this is indeed the case if the electrodes are completely separated by the diaphragm, the use of which merely converts the one cell into two. But if the electrodes

are not completely separated, and sufficient space is provided below the diaphragm to allow of the passage of liquid from one electrode to another, the element behaves as a simple cell. This is the principle of the author's process, a more detailed description of which is reserved; a plant of 32 cells, however, yielding daily 30 cubic metres of oxygen and 60 of hydrogen, has been working for six months at Tivoli, and the gases are sufficiently pure for industrial purposes, the oxygen containing about 1·5 % of hydrogen, and the hydrogen only a trace of oxygen. J. W.

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960. *Cowper-Coles Gold-Recovery Process.* **S. Cowper-Coles.** (Elect. Rev. 42. pp. 779-780, 1898.)—The principal feature of the Cowper-Coles process for the Recovery of Gold from Cyanide solutions is the use of an aluminium kathode, which overcomes one of the chief difficulties appertaining to the economical recovery of gold from weak cyanide solutions by electrolysis. In the Siemens-Halske process lead foil or lead strips are used, the cutting up of which is a tedious matter. If several sheets are cut superimposed, the strips cling together, and have to be carefully spread out one by one, so that the surface may be exposed to the solution. A clean up is made every 7 to 8 weeks, when the wood frames carrying the lead strips are withdrawn, the lead strips removed and new substituted, the auriferous lead being ultimately melted down and conveyed to a central works to be cupelled. This method is both crude and expensive, the labour of fitting the strips into the frames is considerable, and the consumption of lead is a large item, having been computed by Von Gernet at the Worcester Mine at 1·10 of a penny per ton of ore treated. The author overcomes these difficulties by substituting aluminium plates for the lead-foil, advantage being taken of the fact that a loose oxide is formed on the surface of the aluminium which enables the deposited gold to be readily stripped or wiped from the kathodes as pure gold. Gold by this process has been successfully extracted from cyanide solutions containing only ·01 per cent. of potassium, $2\frac{1}{2}$ dwts. of gold to the ton of solution. The substitution of aluminium for lead foil or strip, enables the gold to be obtained as pure gold, and also daily returns to be made of the amount of gold recovered; it has also the additional advantage of reducing the cost of labour, and economising the amount of cyanide of potassium used, as the solution is not contaminated by any base metals, such as zinc, as in the MacArthur Forrest process. AUTHOR.

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961. *Electrolytic Production of Aluminium at Foyers.* **R. W. Wallace.** (Soc. Chem. Ind. Journ. 17. pp. 308-314, 1898.)—A high-level tunnel leads the water from above the Falls of Foyers to six lines of cast-iron pipes communicating with the turbines, which, with the factory, are on low-lying land near Loch Ness. In order to equalise the flow of water, a dam has been built above

the Falls, uniting two small lochs into a reservoir capable of holding about 4,000,000,000 gallons, at a height of about 700 ft. above Loch Ness. Penstocks are provided in the dam, so that the water from the reservoir may be utilised to any desired extent when the water draining from the hills is insufficient. At present there are in use 5 large turbines and dynamos, each of about 700 E.H.P., and two others of equal size are in course of erection. The dynamo and turbine rotate on the same shaft at 150 revs. per min., and each dynamo gives 8000 amps., at a cost of less than one third of what it would be if generated by coal and steam-power. The Héroult process is used, alumina being charged into the fused cryolite constantly as aluminium is deposited; the temperature of the electrolyte is between 750° and 850°, to maintain which (added to the absorption of energy in decomposing the Al_2O_3) an E.M.F. of from 3 to 5 volts is required, of which theoretically 2·8 volts are used in electrolytic action. About 8000 amp. per cell are employed, which is equivalent to C.D. of 700 amp. per sq. ft. of kathode-surface, and 35 amp. per sq. in. of anode area. The practical yield of metal is 1 lb. per 12 E.H.P. hrs. Pure alumina is used, and the carbons are specially prepared by the Company, so that they shall not disintegrate under the high current density employed, and form short circuits; and so that they shall not introduce impurities into the bath. Theoretically, the weight of carbon used up should bear to that of aluminium reduced the ratio 2 : 3, but in practice it is about 1 : 1.

In the discussion, in reply to Vautin's statement that pure Al_2O_3 could be made by a new process for from £3 to £4 per ton, it was elicited that the company's production of this material cost £12 per ton. It was also stated that the cost of power at Foyers was about 30*s.* per H.P. per ann., exclusive of interest on capital, as against £9, which was Prof. Kennedy's figure for steam-power in Scotland with coal at 3*s.* 6*d.* per ton. Finally, it was said that no fluorine was evolved during electrolysis, provided that the voltage did not exceed 3 to 5, the voltage theoretically required for decomposing aluminium fluoride being 4, and that for sodium fluoride 4·7 volts. W. G. M.

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962. *Castner-Kellner Alkali Works.* **J. B. C. Kershaw.** (Electricity N. Y. 14. pp. 293–294, 1898.)—In this article upon the Electrochemical Industries of England, the author gives some financial details concerning the Company owning the above works. The article opens with some remarks concerning the growth of industrial Electrochemistry in Europe during the period 1878–98, and then passes on to the history of the Company. The work of the first section of the plant (1000 H.P.) has been satisfactory, and the extension of the works to the originally designed capacity of 4000 H.P. is now being rapidly pushed forward. The company has arranged with the German "Solvay" Company to accept delivery of their total output of bleach at a fixed price for a period

of 3 years, and is thus ensured of a market for their chief product. The second 1000 H.P. installation is to be used for the production of caustic potash in place of caustic soda. The Mathieson Alkali Company of U.S.A. are working the same process at Niagara with 1500 H.P. from the Falls. AUTHOR.

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963. *Treatment of Sulphide Ores containing Lead, Zinc, and Silver.* **O. J. Steinhart.** (Indus. & Iron, 24. pp. 262–263, 282–283, 1898.)—The author alludes to the treatment of these ores by the processes of Létrange, Lambotte and Doucet, Cassel and Kjellin, Siemens and Halske, Sinding-Larsen, Cowper-Coles, Herrmann, Nahnsen, Lindeman, Hoepfner, Bridgman, Hurter, United Alkali Co., Brewer, Emmens, Wilde Kynaston and Brock, Parker and Pullman, Ashcroft, Dieffenbach, Lorenz, Borchers, and others.
W. G. M.

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964. *Electrolytic Hypochlorite.* **A. Volta.** (Elettricità, Milan, 17. pp. 312–314, 1898.)—In Tailfer's process for the electrolytic production of sodium hypochlorite, the electrolysis is effected in a vessel divided into two concentric departments by a diaphragm of asbestos, the inner compartment containing the kathodes of gas carbon, the outer, iron anodes. The chlorine and soda produced by the electrolysis of the salt solution are conducted to a special absorbing vessel, where the hypochlorite is formed by their admixture, which thus takes place *outside* the electrolytic cell. This is the special feature of the process. The product thus obtained has a strength of 20°–35°, *i.e.*, contains 20–35 times its volume of available chlorine, whereas by the Hermite process the strength of the liquid is at most 1°·5–2°. The electrolyte employed contains 250 grams of sodium carbonate per litre; working with 100 amperes at 100 volts, 20 hours suffice to produce 800 litres of solution at 30° strength, equivalent to 400 kilogrammes of hypochlorite. The cost of production is said to be only one-third of the present market price of the hypochlorite. J. W.

GENERAL ELECTRICAL ENGINEERING.

965. *Fulmen Accumulator.* (Elect. Rev. 42. pp. 786–787, 1898.)—The essential characters of accumulators for motor-carriages are high specific power (watts per kilogram of weight) and high specific energy (watt-hours per kilogram of total weight), in order that the dead weight carried shall be as small and the length of journey as great as possible. In these respects the type of accumulator described (B_{13}) is considered to be superior to all others examined. There are 13 plates, 6 positive and 7 negative, which are 18·5 cm. high, 9·5 cm. wide, and 4 mm. thick; they consist of blocks of 24 rectangular cells, charged with the active material, and are prevented from touching by sheets of celluloid. These partitions, with the celluloid trough, weigh 600 grams, while the complete element with the liquid is 7·5 kilograms. The weights of the moist positive and negative plates are 475 and 390 grams respectively, the grid in each case being only 135 grams. The normal discharge is 21 amperes during 5 hours, the mean E.M.F. being 1·9 volts, and the capacity 105 ampere-hours. Each element supplies 40 available watts and contains energy equal to 200 watt-hours. The constants of the element per kilogram of total weight are: specific output, 3 amperes; available specific power, 5·3 watts; specific capacity, 14·6 ampere-hours; available specific energy, 26 watt-hours. The specific weight is 190 kilograms per kilowatt, or 37·5 kilograms per kilowatt-hour. J. W.

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966. *New Storage Battery.* (Elect. Rev. N.Y. 32. p. 268, 1898.)—This is a description of a high tension or "series" battery designed by N. H. Edgerton, and installed at Souderton, Pa., U.S.A. The plates are 6 feet wide by 7 feet high, and are piled horizontally upon one another, each being positive on its upper and negative on its lower side. The upper or positive surface is covered with a thin layer of asbestos, and then a layer of pulverised oak-charcoal which keeps the plates apart and also acts as an absorbent for the electrolyte, so that no containing-vessel is needed for the battery. There are 110 plates forming a pile about 7 feet high and having a total weight of 16 tons. The open circuit E.M.F. of the battery is 225 volts and its capacity 300 ampere-hours. E. J. W.

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967. *Storage Battery Meter.* **W. S. Aldrich.** (Elect. Rev. N.Y. 32. p. 251, 1898.)—The Thomson meter, as modified for use with storage batteries, runs more slowly forward during charging than backward during discharging, the ratio of the speeds being adjusted to suit each case, so that the reading always represents the nett amount of energy available from the battery. For electric carriages and launches a meter of this kind is very necessary, to indicate the condition of the battery. A. H. A.

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968. *Electric Meter.* **W. D. Marks.** (Frank. Instit. Journ. 145. pp. 309–310, 1898.)—This meter, for the three-wire system, comprises two solenoids and cores placed above a self-starting pendulum actuated by the electric current. This pendulum, by means of a cam, raises a pawl on a ratchet-wheel to a uniform height each stroke. The solenoids, by means of their cores, alter the angular position of a pendant arch attached to their axis so as to allow the pawl to drop along the ratchet-wheel a number of teeth proportional to the current passing through the meter. Thus, at each stroke of the pendulum, the load in amperes passing to the consumer is measured, and the ampere-hours added up by means of the ratchet-wheel and a dial-register. A pointer and scale are also provided for indicating the current in amperes flowing at any time. A photograph of a 22-light meter, showing the working parts, is given in the original paper. C. K. F.

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969. *Lightning Arresters.* **A. H. Gibson.** (Elect. Rev. 42. pp. 762–763, 1898.)—The author describes the effect of lightning discharges upon a 3000-volt power transmission plant in South Africa. The arresters used consisted of copper wires supported on porcelain insulators, and shaped like the Thomson-Houston arresters, but without magnetic blow-outs; the arc is carried upwards by the heated air, increasing in length until it breaks. An arrester was fixed upon each line, with a separate earth-plate; the resistance between two earth-plates, each 5 ft. × 3 ft., and near together, was 20 ohms. The nature of the discharges is described, and most of them attributed to secondary effects rather than to the line itself being struck. Smooth-core drum armatures are peculiarly liable to damage, while armatures with slotted cores seldom suffer. A. H. A.

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970. *Electric Wiring Practice.* **F. Bathurst.** (Elect. Engin. 21. pp. 664–667, 1898.)—The problem, with which the author concerns himself, is how to best instal the conducting wires of electric light or power installations, upon the consumer's premises, with due regard to safety and convenience, and at the same time instal electric wiring work which shall be in all points as durable and satisfactory as the present standard of work for gas or water. The author points out that although the Central Electricity Supply Stations are supplying upwards of 300,000 H.P. of electrical energy, the number of incandescent electric lamps at present installed represent only about 1% of the total amount of the gas-lighting that is carried out in the cities and towns of England; and he argues that, looking to the steady and continued progress electrical applications are all the while making, the question of good or bad electric wiring has become a matter of great and increasing importance. In fact, the position of the art

of wiring is now dominating the progress of extended electrical application and affects the immediate prosperity and future of the whole electrical industry.

(*Conditions.*)—It is now becoming generally understood that when electric wires are imperfectly installed, the electricity escaping from them can, under suitable and only too liable conditions, set fire to their surroundings, causing fires which are insidious in their character and which usually destroy all evidence as to their origin. The principles which underlie effective construction are dealt with. Conducting wires, although designed to carry current proportionate to their sectional area, will carry any current that may be passed through them, becoming, perhaps, in so doing overheated, and setting fire to the insulating covering around them. Hence, with electric wiring the possibility must be faced of injury occurring to the wires from within themselves, a condition of service very different from that holding in gas practice. In comparing the electric wire and its insulating covering with a gas-pipe, it is shown that the copper conductor is equivalent to the orifice of the gas-pipe, whilst the frail insulating covering is to be compared with the coating material (usually iron) forming the gas-tube. From mechanical considerations, therefore, insulated electric wires installed without other protection, compare with a gas service furnished through *rubber* tubes. The author refers to experiments which prove that when the insulation is arranged in the form of a surrounding tube, instead of being placed directly upon the conductor, the heating troubles referred to above are satisfactorily met. Experiments are also shown as to the limitation and unreliability of "safety fuses" usually put in circuit with the conductors to protect them from becoming overheated, and how insulating covers in a tube form can, in great measure, be used *instead* of fuse protection. Comparison is also made with gas service, showing how electric wiring is at a disadvantage by the presence of moisture, as, although insulating materials will withstand "pressure" or "voltage" when in a perfectly dry state, they are valueless when mechanically damaged or affected by moisture; and also how the leakage-current may, without giving immediate indication, by gradual corrosion destroy both the insulating covering and the conducting wire itself.

In good electric wiring, therefore, certain electrical, chemical, and mechanical conditions have to be guarded against, in order to prevent possible injury, both from within and without the electric circuit. The term "circuit" as applied to electric-light wiring, implies the use of two distinct wires, usually laid close together, one used as the "lead" from, and the other for the "return" of the current to the point of generation; and, holding to the gas-pipe analogy, the construction involved can best be grasped by imagining it necessary to provide a second and supplementary system of piping which would act as an exhaust system for collecting the products of combustion, in order to return them to the gasometer.

(*Practice.*)—Although 10 years have elapsed since electricity supply from Central Stations was first undertaken, there is as yet no generally recognized system of electric wiring which is permanent and satisfactory, as is the "iron-piping" standard in gas practice. The author condemns the "wood-casing" method, hitherto so general, as only an intermediate stage in electric-wiring practice, and makes experiments showing how readily a fire results from "overheating" or "leakage" trouble, where the conductors with imperfect or damaged insulating covering are lying on damp wood. The weakness is virtually admitted from the fact that wood-casing work must never be concealed; that is, it is necessary to have the wires and fittings "readily accessible" for easy inspection or replacement. He shows that the boxing-in of wires and joints tends to the existence of slip-shod and shoddy work, which no method of testing can discover, and no one dare guarantee for durability. This fact is made use of at present by any unscrupulous wiring contractor, and is said to account for the immense difference to be seen in the tenders submitted for wiring work. The author points out that wood-casing work is now prohibited in Germany, and is practically obsolete in the U.S. of America, where enlarged spheres of electrical application have provided the necessary and extended experience. He also refers to the fact, that although the experience of our Fire Offices may so far be deemed satisfactory, their present attitude towards new methods of work is not encouraging and may in time re-act injuriously to themselves. The increasing necessity for *concealed* work and a standard of practice analogous to that holding for gas service, is creating demand for systems other than wood-casing. The author, however, maintains that insulated conductors protected with a light lead sheathing, or even if enclosed in an ordinary metal pipe, are not desirable or suited to high-class installation work, and advocates as a standard method the use of insulating pipes or conduits, which, until an insulating material can be produced which is as hard as iron, should, for the best class of work, be mechanically protected by an iron or steel covering. A system of armoured insulating conduits can be installed in a building in the same manner as an iron gas-pipe system, and provides all the requirements for perfect electrical service. An insulating tube system is the only one which complies with the "arc proof" conditions necessary and provides installation which is free from electrical fire risk. With its general adoption contractors would not have to submit to the ineffective and oftentimes annoying inspection on the part of the Fire Office authorities, for the fire "possibility" arising from ignorance or carelessness on the part of the workman is counteracted or checkmated by the use of such material. Experiments are shown to prove the advantages of lined metal pipes over ordinary metal pipes, in respect to smoothness of interior, "bending," easy "drawing-in," simplicity of erection, non-liability to internal "sweating," and "arc proof" resisting qualities, etc., and the author concludes by pointing

out that an insulating conduit system of wiring provides in the highest degree the cardinal points of good wiring, namely, safety, durability, convenience, accessibility, and ultimate economy.

AUTHOR.

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971. *Insulators.* **A. T. Bell.** (Elect. Rev. N.Y. 32. pp. 186–187, 1898.)—Small glass insulators do not puncture at 40,000 volts because they avoid it by surface leakage. Porcelain does not do this. Electrical defects in glass are no more discernible with the eye than in porcelain. Annealing only diminishes the brittleness of the glass body as a whole, so that when part is broken off by a stone the whole insulator "flies." The non-use of glass in England is due to the moisture of the air. *Multi-glaze* insulators are criticised by the assertion that glaze is known to be the weakest and most absorbent part of good table china. The six coats of glaze used increase the chances of trouble. Under a test, one of the petticoats of some *multi-glaze* insulators were broken and the whole soaked in salt water. They failed to withstand the same pressure as single-piece insulators similarly treated. Dr. Perrine's statement is endorsed, viz., "Only that amount of glass should be present (in the porcelain) which will fill up the porosity of the dehydrated silicate of alumina"—thus avoiding the brittleness of glass. The appearance of the fracture will detect glassy paste. Insulators should be tested before they are glazed and retested after the second fire in the glost kiln, at 25,000 to 100,000 volts. M. O'G.

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972. *Insulators for High-Tension Lines.* (Électricien, 15. pp. 212–219, 1898.)—The paper is a description with scale-drawings of new types of insulators for overhead lines capable of sustaining pressures up to 10,000 volts. They are manufactured by Burns et C^ie^, Paris. The insulator for 2000 volts has one internal petticoat only, but the outer surface of this has four ribs or what may be termed horizontal petticoats; this insulator, 8 cm. high and 9 cm. in diameter, presents a length of insulating surface of 26 cm. The insulator for 10,000 volts has two internal petticoats, the outer one quite short and the inner provided with two horizontal petticoats; the upper of these nearly touches the outer petticoat and the lower passing below it nearly touches the inner surface of the insulator bell. This arrangement produces three nearly closed annular chambers, into which it is difficult for moisture or dust to penetrate. The larger size, 9 cm. high by 115 cm. in diameter, has an insulating surface 30 cm. long. A heavy type is made for withstanding side pulls up to 400 pounds. For lower pressures, to take heavy pulls up to 600 pounds, as at angles or at the ends of lines, the insulator is held by a vertical bolt passing through it and fixed to an iron fork; above and below the central groove for the wire is a double petticoat. A high-tension line switch is constructed as follows:—An iron rod

is fixed to a cross-piece on the pole, its ends passing through caps cemented on to the tops of two insulators; pins cemented into these insulators terminate below in spring contacts, and contact is made by a metal bar provided with insulating handle. This bar is prevented from slipping out of the contacts by a copper wire passing through contact piece and bar, and fine enough to break easily in pulling down the bar. This bar is also made to take a fuse. G. H. Ba.

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973. *Submarine Boat 'Argonaute.'* **G. Dary.** (Électricien, 15. pp. 209–212, 1898.)—The object of this boat, built by S. Lake, Baltimore, is to facilitate the work of divers on sunken ships. When floating on the surface of the water it is propelled by a screw; when sunk to the bottom of the sea, it rests on three large wheels, a pair of which can be driven by a motor. In shape it is like an ordinary cigar-shaped boat, 11 metres long, 2·75 metres diameter. The hull is capable of resisting a pressure of 5 or 6 atmospheres, so that it can sink to a depth of 50 metres. The hull is divided into 4 compartments, in the largest of which the motors and crew are placed. The divers ready for work enter a second compartment, usually at the same air-pressure as the first, but in which the air-pressure is raised by pumps until it is equal to the exterior pressure. The divers then enter a third compartment, which by an opening at the bottom of a small ladder, gives access to the bottom of the sea. The fourth compartment at the bow contains a powerful search-light. Two tubular masts are used, and when the depth is not too great serve for ventilation; if the depth is greater than the height of the mast, the air-reservoirs permit submersion for 48 hours. The first trials have been satisfactory. A. S.

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974. *Diesel Heat Motor.* (Electrical World, 31. p. 242, 1898.)—This new gas-engine, designed on a novel principle, and giving remarkable results, was described by Rudolph Diesel at a meeting of the Deutscher Ingenieure Verein, on June 16, 1897. He set forth four essential conditions for an economical engine in which the combustion takes place inside the working cylinder:—

1st. The temperature of combustion must be generated, not by and during the burning of the fuel, but before and independent of it, by mechanical compression of air. 2nd condition of this rational motor is, that the temperature of combustion is obtained directly by adiabatic compression of the air. 3rd condition, that the fuel must be introduced gradually into this compressed air in such a manner that the heat generated by gradual combustion (isothermally) is converted into work by the expansion of the air and gases without increasing pressure, similar to the admission pressure on the indicator diagram of a steam-engine, the point of cut-off being initiated by the stopping of the fuel supply. The burnt gases then expand adiabatically to the point of release, and

fresh air is again compressed adiabatically to the temperature of ignition before the introduction of the new charge. 4th condition, that the combustion should be carried on with a considerable excess of air, instead of with as little surplus as possible.

The Diesel experimental engines so far constructed have been of the single-cylinder four-cycle single-acting vertical type. One of 20 horse-power, working with refined petroleum, was tested by Professor Schröter in 1897. The engine-cylinder is water-jacketed, and provided with valves, operated by cams, for admission and exhaust. A small pump keeps an auxiliary vessel filled with air compressed to a higher pressure than that obtained in the cylinder. This air, compressed to about 40 atmospheres, serves to start the engine and inject the fuel. The indicator diagrams are similar to those of a steam-engine with admission pressure of 35 to 40 atmospheres, and early cut-off. The mean speed during the test was from 154 to 172 revolutions per minute. The ratio of the indicated work during compression to that during expansion showed an average of about 50 per cent. for full and half loads. The mean effective pressure in the working cylinder was about 100 lbs. per square inch at full load, and 70 lbs. per square inch at half load. The mechanical efficiency, that is the ratio of the brake or effective work to the indicated work, varied from 75 to 58 per cent. as the work was varied from full to half load. The consumption of petroleum per brake horse-power was about 0·24 kilogram (0·53 lb.) at full load, and 0·28 kilog. (0·61 lb.) at half load. Tests of the calorific value of the fuel showed that from 22 to 25 per cent. of the available energy of the fuel was converted into useful work on the brake. W. R.

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975. *Use of Exhaust Steam.* **A. H. Perkins.** (Elect. World, 31. p. 438, 1898.)—The author calculates the percentage of extra steam required in an engine, as the back pressure is raised above that of the atmosphere. From these calculations it is readily seen when it is economical to use exhaust steam for heating or drying, or when it is better to heat with live steam. It will not pay to use exhaust steam unless the amount so used for heating exceeds the quantity of extra steam required on account of raising the back pressure. The author discusses a case in which exhaust steam from a Buckeye engine was used to heat 13 driers, in which case the heating by direct steam showed a saving as compared with heating by exhaust steam. A. S.

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976. *Failure of Copper Steam-Pipes.* **J. T. Milton.** (Mech. Eng. 1. pp. 478–480, 511–513, 1898.)—An inquiry into the cause of an explosion of a copper steam-pipe on the s.s. 'Prodano' in June 1897, was held in August 1897, before three Commissioners in London. The findings of the Court are given and are discussed by Mr. J. T. Milton, the chief engineer to Lloyd's

Registry, who also gives a list of exploded steam-pipes which have been inquired into under the Boiler Explosions Acts. Professor Arnold made a micro-chemical determination of the causes which led to the explosion, and comes to the following conclusions:—(1) That the brazing of the 'Prodano's' pipe was originally sound, of good workmanship, and composed of a suitable alloy. (2) That the explosion was due to a gradual removal from the greater part of the brazing of about half its zinc, the remainder being converted into oxide, and thus leaving a spongy, and hence brittle, mass of metallic copper possessing little cohesion. (3) That the disintegration described above was electrolytically brought about by the presence in the pipe of water containing small quantities of fatty acids which formed organic salts of zinc, either fusible at the temperature of the pipe or soluble in hot water. (4) That the fatty organic acids must have reached the main steam-pipe *via* the piston-rods, cylinders, condensers, and boilers, and that fatty oils must have been employed either inadvertently as adulterations in mineral oil, or deliberately in the form of lubricants, such as tallow or castor-oil. A. S.

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977. *Variable Efficiency of Steam Boilers.* **F. G. Gashe.** (Indus. & Iron, 23. p. 421, 1897; 24. pp. 148–149, 167–168, & 183–185, 1898.)—When the temperature of the combustion-products is lowered to that of the steam, it is evident that all the available heat has been utilised. The prevalent methods of conducting boiler-trials do not recognise sufficiently the important influence of the rate of combustion of the fuel. The average rates of supply of feed-water and fuel over the portion of the trial during which they are uniform should be taken, instead of the totals over the whole period. $E' = C/1 + AR'$; where E is the evaporative power, C and A constants, and R′ the fuel per square foot of grate surface. The results of 16 trials on a 72 in. × 20 ft. horizontal tubular boiler are given. The performance of a boiler should be derived from a series of trials in which the rate of combustion is deliberately varied. Intimately connected with boiler-performance is that of the feed-heater.

The paper is followed by a discussion. A. S.

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978. *Water-Tube Boilers.* **G. Haliday** and **R. Seabury.** (Indus. & Iron, 24. pp. 366–367 & 428–429, 1898.)—A paper read at the Institute of Marine Engineers, in which most of the commercial types of water-tube boilers are described and discussed. A. S.

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979. *Steam Consumption of Auxiliary Apparatus of U.S. steamer 'Minneapolis.'* (Elect. World, 31. p. 383, 1898.)—The apparatus for testing the auxiliaries was primarily arranged to find the steam-consumption of the dynamo engines, the pistons of which

had no packing-rings but were grooved for water packing. The engines were afterwards supplied with new pistons and packing-rings. The steam-consumptions before and after the change were respectively 123 lbs. and 69 lbs. of steam per I.H.P.-hour. The steam per I.H.P.-hour on some of the auxiliary engines varied from 55 lbs. on a circulating pump-engine of 19 I.H.P., to 319 lbs. for a duplex fire-pump of 0·8 I.H.P. A. S.

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980. *Steam Value of Three Kinds of Coal.* **A. Baldasano** and **W. J. Beach.** (Street Rly. Journ. 14. p. 199, 1898.)—The paper contains tables and diagrams of data and results of experiments made on a Babcock and Wilcox boiler. The boiler efficiencies at different rates of combustion were measured. In all three tests the evaporation is greatest with the lowest rate of combustion, an increase in the rate of combustion shows a diminution in the rate of evaporation; but in two out of the three cases a still higher rate of combustion increases the rate of evaporation. A. S.

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981. *Safety Devices for Steam and Power Plants.* (Street Rly. Journ. 14. pp. 291–292, 1898.)—A description (1) of the 'Monarch' *engine stop*, which is attached to the stem of the throttle-valve by means of a sprocket-chain, and is operated by pressing a push-button, any number of which can be placed in different positions as required; and (2) of the 'Monarch' *speed-limit*, in which two governor-balls are arranged so that when a predetermined speed is reached, an electric circuit is closed, bringing into action the engine stop and shutting down the engine at once. A. S.

DYNAMOS, MOTORS, AND TRANSFORMERS.

982. *Non-Insulation of Bolts in Armatures.* **J. Fischer-Hinnen.** (Ind. Elect. 7. pp. 105–107, 1898.)—It is generally believed that the non-insulation of the extremities of bolts which traverse the stampings of armatures may lead to losses of energy, since a closed circuit is formed by the bolts and the two-end stampings of the armature. The author investigates the subject theoretically, purposely assuming conditions most likely to give exaggerated results, and finds that in the case of 180 kilowatt machine the loss due to six bolts is only 5·3 watts. He concludes, therefore, that the loss is in general negligible. W. G. R.

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983. *Commutator Sparking.* **T. Reid.** (Amer. Instit. Elect. Engin. 15. pp. 33–60, 1898.)—The author considers that the theory that injurious sparking is due to the current sparking across the gap between the brush and the receding segment, by reason either of incomplete reversal of the current or of over-reversal, is insufficient, and attempts to show that sparking from either of these causes may be harmless, and that the real injury is done before the segment leaves the brush. Perfect commutation may be defined as a complete reversal of the current in the coil under commutation in such a manner that the portions of the current flowing through the two segments to which the ends of the coil are connected, shall be proportional to the respective contact areas of the segments. There are various ways in which imperfect commutation may occur. If the current across the contact surface of the receding segment does not decrease as rapidly as the contact-surface decreases, the current-density will increase and will be a maximum at the last part of the segment that touches the brush. More energy is concentrated at that point than at any other, and it will be raised to the highest temperature. This temperature may be high enough to melt or volatilize the copper of the segment; when the brush leaves the segment, the current continues to flow through the film of melted copper and draws an arc. This is the injurious spark. The spark which occurs when the copper is not melted has no injurious effect. The same thing may occur at the entering edge of the segment, but in this case no spark will appear: the melted copper will be carried along by the brush and the entering edge of the segment is gradually eaten away. The reversal E may be large enough, not only to reverse the current in the coil under commutation, but to increase it beyond the value of half the brush-current. In this case, since the receding segment is reducing its area while the current is increasing, that segment will get hottest. The variation of the brush-contact resistances aids the reversal of the current; as soon as this current becomes greater than that

which flows through the armature, the excess current must pass across the contact areas of both the segments under the brush. These two contact surfaces are in series as regards this current, and the lowest possible resistance they could have, would be when the brush covers an equal surface on each segment. The resistance of this part therefore starts at infinity, decreases to this minimum, and goes back to infinity again. If there were no contact-resistance the current would reach its normal full-load value at about the middle of the commutation period, assuming that the reversal E is able to reverse the current at full load without the aid of the contact-resistances. In fact the reversal E does a very small part of the reversing at full-load when the inductance is small compared with the contact-resistances. There are two ways by which sparkless commutation may be assured: by increasing the brush contact-resistance, or by decreasing the impedance. The limitation of the first of these conditions is the heating of the commutator. The increasing use of the carbon brush is thus explained by the fact that the contact-resistance of carbon on copper per square inch is much greater than that of copper on copper.

In the discussion on Reid's paper, **G. S. Dunn** says that he considers that the resistance of the brush affects commutation more than the contact-resistance of the brush on the commutator. A carbon brush which will stop sparking on a 25 H.P. motor wound for 110 volts, will not stop sparking when the same motor is wound for 500 volts. But a graphite brush, or carbon brush of much higher resistance will stop it. Where a copper brush will not stop sparking on a 110-volt dynamo a copper gauze brush will, because of the higher resistance of the gauze, not because of the diminished contact area resulting in higher contact-resistance.

Dunn proposes a method of dividing the reactance of the armature into its inductive and ohmic terms. The armature is put into its bearings away from the influence of any field, the full-load current is passed through it, and the volts across the brushes measured. This gives the drop due to the ohmic resistance of the conductors and the contact-resistance of brushes. The armature is then driven at its full speed with the same current, the volts will go up, the difference after allowing for contact and brush resistance will give the reactance of the armature directly in volts. On 230-volt machines with carbon brushes, commutation will take place sufficiently well for heavy duty with a reactive voltage of 2 volts. If the machine is used for intermittent work and has to have its brushes in the middle, this may be increased to 5 volts. In 500-volt machines with graphite brushes, the reactive volts may be twice as high.

Steinmetz thinks that the friction of the brush must be considered; the C^2R loss varies with the load, but the friction loss is constant. In a 50-volt machine the friction loss may frequently be as much as 5 per cent. or more of the output

of the machine. He considers that with ordinary carbon brushes the internal resistance of the brush is negligible compared with the contact-resistance. The effect on commutation is very nearly the same whether the resistance is in the contact or internally. R. B. R.

984. *Induction Motor.* **A. E. Wierner.** (Amer. Electn. 10. pp. 193–194, 1898.)—In this article is given a neat way of showing the motion of a revolving field, suitable for lecture purposes. By a kinetoscopic arrangement of sheets of paper containing diagrams of the rotary field in proper succession and exactly concentric with each other, a good representation of a revolving field may be obtained. When passing the sheets in one way the revolving field is seen to rotate in one direction, and on moving the sheets backward, the rotation is in the opposite direction. W. G. R.

985. *Improving Power-Factor of Induction Motor.* (Elect. World, 31. p. 585, 1898.)—A brief notice, with some criticisms, of the arrangement recently patented by **C. P. Steinmetz** for increasing the power-factor of induction motors. In the case of a single-phase motor, a tertiary winding is provided on the core of the primary, and connected to a condenser. This winding is so arranged relatively to the primary as to be inoperative so long as the rotor is at rest. As soon as the latter is started, however, the reaction of the currents induced in its windings sets up an E.M.F. in the tertiary, and the condenser connected to the latter gives leading currents which react on the primary and secondary, and neutralise the "idle" currents in these circuits. A. H.

986. *Current Transformers.* **C. T. Child.** (Elect. Engin. N.Y. 25. pp. 573–575, 1898.)—The author discusses the various methods of transforming alternating into continuous currents and *vice versa.* The use of rectifiers is restricted, on account of sparking difficulties, to comparatively small currents (10 amperes). Their efficiency is very high, but a serious disadvantage is the extra strain imposed on the insulation in consequence of the maximum potential difference considerably exceeding the R.M.S. value. If the transformation involves large currents, and if these are not to be fluctuating, one or other of the following 3 methods may be used:—(1) a dynamo driven by a synchronous motor; (2) a rotary transformer, with either single or double winding: (3) a machine of the type devised by Hutin and Leblanc, and called by then "panchahuteur." The 1st method has the advantage that the direct-current E.M.F. is independent of that of the alternating current, and may be adjusted through a considerable range if desired. Further, if the alternating current be fed into the stationary part of the motor, very high E.M.F.s may be used,

without the intervention of stationary transformers; and lastly, the frequency may be chosen without any reference to the direct-current end of the machine. The main disadvantages of the method are high cost and comparatively low efficiency. The method involving the use of a double-winding rotary transformer effects considerable saving in material; but many of the advantages which characterise the 1st method are sacrificed. Double-winding rotary transformers are not much used.

[*To be continued.*] A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

987. *Regulation in Central Stations.* **W. H. Chapman.** (Amer. Electn. 10. pp. 206–207, 1898.)—This paper, after treating the subject of regulation generally, fully describes an arrangement successfully used by the author for preventing variations of voltage or current according as the basis of regulation is constant potential or constant current. The actual detector is a solenoid with a laminated plunger connected to one end of a lever, with a movable counterbalance weight at the other end; the movement of this lever closes a pair of electrical contacts at one side or the other. The connecting link between this detector and the regulating rheostat consists of two differentially wound solenoids having a common core; each solenoid has two similar windings, in one of which there is always current, hence the core is always magnetised and acted on by two equal and opposite forces. When the second coil is put in on either solenoid by the contact points of the detector, that solenoid is neutralised and the other moves the core, putting in or taking out resistance in the rheostat. By means of this arrangement all sparking caused by induction is effectually stopped. The paper contains a sketch of the above arrangement showing several ingenious devices for fine adjustment of the working parts. M. G. W.

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988. *Distribution of Electrical Energy in Paris.* **J. Laffargue.** (Elect. Engin. 21. pp. 519–523, 562–564, 627–629, 649–650, 1898.)—In the end of the year 1888 the Municipal Council of Paris granted concessions to certain companies for the distribution of Electrical Energy. The main conditions imposed were as follows:—The authority to lay cables in Paris was granted for 18 years, the mains everywhere to be underground. The tariff to be fixed by the company but not to exceed 14·4*d.* per kw. hour for lighting, and 6*d.* for motive power. Municipal dues amounting to £4 per annum for every kilometre of conduits laid and 5 % on returns to be paid. The area of supply to have form of a sector passing from the centre of the city to the circumference. Since 1888 six companies have taken up concessions, and the city of Paris has established municipal works at the Halles Centrales. A map is given in the article showing different areas of supply and the position of the stations. The author then describes the systems, etc. of the various companies.

Edison Continental Company.—The distribution is by continuous current with 3-wire feeders in ring circuits, with 120 volts between each. The company has 3 stations connected together in parallel, and a substation for accumulators. At the close of 1897 their available power was 3300 kw. in machines and 420 kw. in accumulators.

Société d'Eclairage et de Force par l'Electricité.—The principal station of this company is outside Paris, and besides supplying continuous current to works in the neighbourhood sends continuous current at 2500 volts into the city, which is transformed down by rotary transformers. The company owns several small generating stations in Paris and substations for transformers and accumulators: their total available power is 3820 kw. from machines and 290 kw. from accumulators.

This company has also recently undertaken to supply energy by diphase alternating currents from the works at St. Ouen.

Campagnie d'Air Comprimé et de l'Electricité.—The distribution was originally effected from about 20 substations drawing continuous current at 3000 volts from two generating stations connected in series. The company has now abolished most of the substations, and is supplying current at 500 volts direct to the distributing networks from a large new station. The total power at the new station is 3600 kw., and 2325 kw. at the two old works.

Municipal Works at the Halles Centrales.—These works are chiefly for the purpose of public lighting, but a few private consumers are supplied; they have a direct-current distribution at 120 volts, and an alternating system at 2400 volts which is transformed down to 220 volts. The total available power is 325 kw. in continuous, and 330 kw. in alternating machines.

Société de la Place Clichy.—The distribution is by the 5-wire system with accumulator and regulating stations; at their generating station the company have at their disposal machines yielding 2300 kw. Data of some interesting experiments with anthracite coal made at this station are given in the paper.

Société du Secteur des Champs Elysées.—This company has a large district and has adopted alternating currents at 3000 volts with transformers for each consumer; it has one central station, producing 1800 kw. The distributing cables are armoured and laid direct in the ground. The company has 50 motors equivalent to 220 H.P. connected to its mains.

Société du Secteur de la Rive Gauche.—This company did not commence work until 1896; it has one generating station outside Paris, and distributes its energy by alternating currents at 3000 volts with transformers in substations or on the consumers' premises. The power at present installed is 1600 kw., but the company is extending rapidly.

In conclusion the author states that the total power available at the works in 1896 was 17,775 kw. from machines and 1610 kw. from accumulators, and adds tables as to existing charges, etc. The article is well illustrated by photographs. M. G. W.

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989. *Cost of Electrical Energy.* **R. Hammond.** (Journ. Inst. El. Eng. 27. pp. 246–378, 1898.)—The author gives a large number of data relating to the working of about 80 existing stations

in Great Britain and Ireland. Twenty tables and eleven diagrams are included in the paper. The tables deal with costs per unit, the order of merit of the various stations in relation to different items of cost (coal; oil, waste, water, and stores; wages; repairs and maintenance; rent, rates and taxes; management), comparison of costs, load factor, units used in distribution, variation of cost with the number of units sold, depreciation, etc. The diagrams embody the tabular results in a more convenient form. If the most favourable features of each works were reproduced in one, the energy would be produced and distributed for 0·84*d.* per unit. The various factors in the reduction of cost are considered, viz.:—output, load-factor, reliability of plant, the engineer factor, efficiency of generating plant, efficiency of distribution, and all-round efficiency. The author concludes with a prophecy that when the output at Leeds reaches 5,000,000 units per annum, the works costs will fall to 0·50*d.* and the total costs to 0·75*d.* per unit. It is impossible to more than indicate the scope of this paper in an abstract. W. R. C.

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990. *Power Transmission at Delta, Pa.* **G. R. Stubbs.** (Eng. News. 39. p. 250, 1898.)—This paper describes the plant put down by the Delta Electric Power Co. at the Gartridge Falls, $5\frac{1}{2}$ miles from Delta, to supply power for working slate quarries in the neighbourhood and for lighting the town. A timber crib rock-filled dam 30 ft. high has been placed at the top of a rapid, giving an available head of 42 ft. at the power-house below. The dam is **V**-shaped in plan with a crest 120 ft. long, over which the flood water is discharged. The available power is estimated at 1000 H.P. The plant at present installed consists of two 24-in. McCormick balanced wheels on a horizontal shaft coupled directly to a two-phase brushless generator of 350 kw. The power is transmitted at 5000 volts along a pole-line comprised of four bare copper wires on porcelain insulators; the transmission loss over $5\frac{1}{2}$ miles is about 10 %. The rate to power consumers is 25 dollars (£5 4*s.* 2*d.*) per H.P. year of 10-hour days. The total cost of the present plant has been about £6250, but when additional wheels and generators can be utilised a much better showing as to first cost per H.P. will be possible. M. G. W.

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991. *Blast-Furnace Gas for Electrical Power Transmission.* **W. H. Booth.** (Elect. Rev. 42. pp. 531–532 & 605–607, 1898.)—The author discusses the disposition of the energy supplied to a blast-furnace. The iron, at present considered the primary product, is run off at a temperature of 2800° F., carrying with it heat represented by $1\frac{1}{2}$ per cent. of the total fuel. 3 per cent. of the fuel disappears in the carbon which enters into combination with the iron. Another 3 per cent. disappears in the slag. About 15,000 lbs. of gases per ton of iron leave the furnace at a temperature of 500° F., carrying heat representing $4\frac{1}{2}$ per cent. of the fuel. This leaves about 88 per cent. of the total heat of the fuel carried off in a form not visible as temperature, and representing

the calorific value of the carbon monoxide which forms about 28 per cent. of the effluent gases. It would appear that the power which can be regularly and continuously obtained from a blast-furnace, is 10 H.P. per ton of coal per week; if about 10 million tons of fuel are used per annum in English and Scotch blast-furnaces, then about two million H.P. is running to waste. This power is located at about a score of centres, and might be transmitted by electricity to places where it could be economically used. The whole of the cotton-mills in the country would not absorb a fourth of the supply. There is no difficulty in igniting these poor gases in the cylinder of a gas-engine; gases too dilute to burn in the open, readily ignite when compressed. A. S.

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992. *Blast-Furnace Gases for Motive Power.* **B. H. Thwaite.** (Elect. Engin. 21. pp. 594–596 & p. 623, 1898.)—The author refers to the competition between the three great iron-making countries—United States, Germany, and Great Britain—and to the necessity of improving the industrial procedure if we desire to keep on a level of equality with our foreign competitors. He has fonnd during his prolonged investigations that great thermal economies can be effected in modern blast-furnace plant in the following directions: (*a*) in the combustion of blast-furnace gas for power development; (*b*) in the prevention of waste of gas during the charging operations; (*c*) in heating the air-blast with a reduced expenditure of gas; (*d*) in preventing the entrance of dust into the hot-blast stoves. He has applied the Thwaite-Gardner system of working blast-furnace gas in internal combustion engines at important works in France, Germany, and Great Britain. Whereas with blast-furnace gas-fired Lancashire boilers and good steam-engines, 400–500 cubic feet of blast-furnace gas is required to develop one horse-power hour, with the new system only 80–120 cubic feet are required; the economic advantages of the new system as compared with the old being as four to one. The thermodynamic efficiency of blast-furnace gas for power purposes is actually higher than town or retort gas. The financial value depends on local conditions, but if a demand for power for lighting or other purposes exists within a radius of 30 miles of the iron-works, it can be profitably supplied. The available power has also been applied by the author to the driving of existing blowing-engines. A. S.

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993. *Blast-Furnace Gases for Motive Power.* **A. Greiner.** (Elect. Engin. 21. pp. 660–661 & p. 690, 1898.)—A 200-H.P. engine using blast-furnace gas has been running at the Seraing works of the Cockerill Co. The author compares the utilisation of blast-furnace gas in steam-boilers and in gas-engines, and concludes that the blast-furnace gas is the greatest and surest source of power existing: a surplus of 2000 H.P. per 100 tons of pig-iron produced per week, lying ready to hand.

Objections have been offered to the use of blast-furnace gas in gas-engines on accouut of the dust carried by it, acid matters, and

the irregularity of its composition. These objections are discussed, and the author concludes they have little or no weight; remarking that "it is no more requisite to use thoroughly clean gas in a gas-engine than it is to use distilled water in a boiler." A. S.

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994. *Electricity on a Modern Warship.* **G. H. Shepard.** (Eng. Mag. 15. pp. 280–288, 1898.)—A discussion of the relative advantages of steam-engines and electric motors for the auxiliaries on board a warship. The author's conclusion is that although electric auxiliaries offer many advantages, their great cost and necessary space render them a doubtful benefit, while their great weight absolutely rules them out. But with continued progress, both by makers and users of electric machinery, it will be gradually more and more adopted for special purposes on board ship. A. S.

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995. *Electric Conduit Tramway.* (Electrician, 41. pp. 141–144, 1898.)—A short account is given of the New York Electric Tramway, which was recently completed, with illustrations of the work in progress. A. H. A.

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996. *Chicago Elevated Railway Plant.* **J. R. Cravath.** (Elect. Engin. N. Y. 25. pp. 475–481, 1898.)—An account is given of the South Side Elevated Railroad of Chicago, U.S.A., on which electricity is being substituted for steam. The generating station, of which illustrations are given, is equipped with plant rated at 3200 kilowatts output: a large cooling tower is provided, in which the condensing water is sprayed over sheets of wire netting, and exposed to an artificial draught of air. The third-rail system is used on the line, the rail being placed at one side of the track and fed in sections from a heavy copper main with which the feeders are connected. Each section of rail is supplied through a circuit-breaker, so as to confine the effect of a short circuit to one section. In the yards and shops, where the third rail is inadmissible, an overhead wire is used, making contact with a trolley of arched brass rod $14\frac{1}{2}$ ins. high on the top of each car; the rod is balanced in a vertical position, and yields to the trolley-wire automatically without requiring attention. The Sprague multiple unit system is employed on the trains (see Abstract No. 344). The old cars are being converted by replacing one truck on each car by a motor truck; the change is being made by degrees, without interruption to the train service. A. H. A.

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997. *Cable and Electric Traction in Chicago.* (Rly. World, 7. pp. 111–112, 1898.)—The more frequent the service on a cable line the lower the working expenses per car mile, while on an electric line the expenses per car mile fall off comparatively little by increasing the service. The present cost on the cable lines is $5\frac{1}{4}d.$ per car mile, which is wonderfully low considering the high wages to be paid. The cost on the electric lines is $6\frac{1}{4}d.$ per car mile. A. S.

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998. *Electric Cableways.* **R. Lamb.** (Amer. Instit. Elect. Engin. 15. pp. 3–32, 1898.)—The author describes an electric cableway which has been applied to timber-logging in swamps which would be otherwise quite inaccessible, and to towing canal-boats. The system consists of a carriage with grooved wheels in tandem that moves on the suspended cable. From this carriage is hung a frame pivoted so that it always maintains a vertical position. The frame holds an electric motor geared to an elliptically grooved sheave, around which is wrapped two or three times a steel cable anchored at both ends. The upper or weight-bearing cable carries the electric current which passes through the motor, thence along the traction cable back to the generator. At intervals along the line connection is made between the traction cable and the ground. In logging-plants an electric crane is carried by the carriage.

The paper is followed by a discussion. A. S.

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999. *Waterloo and City Railway.* (Rly. World, 7. pp. 189–192, 1898.)—This paper gives a short account of the construction of the tunnels, the electrical equipment, and the rolling stock. A. S.

1000. *Automobilism.* **P. Simon.** (Électricien, 15. pp. 178–180, 197–199, 250–252, 1898.)—The author gives a simple formula applicable to vehicles whose speed does not exceed 25–30 kilometres per hour,

$$F = PV(K + \tan\alpha),$$

in which P is the total weight of the vehicle and its load, V the speed in metres per second, K the coefficient of traction on the level, α the angle the road-surface makes with the horizontal. He discusses in detail the values which should be taken for the various coefficients, and concludes that a fair average for $(K + \tan\alpha)$ is 0·06. With a maximum speed of 20 kilometres per hour, 4·5 horse-power is required per ton weight; the power along the level being 1·7. These are the powers actually required at the driving-wheels. The author then discusses the relative advantages of steam-engines, oil-engines, and electric motors for auto-cars. A. S.

1001. *Hopcraft's Pneumatic Railway.* (Engineer, 85. p. 328, 1898.)—A working model railway, one-tenth of a mile long, has been made on the system of direct pneumatic propulsion involving the use of no motive mechanism on the vehicle. A motor-tube of heavy canvas, with an inner air-tight tube of india-rubber, which in its normal position lies quite flat, is fixed on a supplementary rail of timber between the ordinary rails. Air under pressure is admitted to this tube, inflates it, and presses against a rubber-tired wheel which can revolve freely on an axle at the centre of the car, and which forms an air-tight joint between the two sections of the tube. A powerful propelling-force is thus exerted against the wheel, causing the car to travel at a speed limited only by the speed of the air in the tube. A. S.

1002. *New Steam and Electric Truck.* (Street Rly. Journ. 14. p. 291, 1898.)—A description of a pressed steel truck for steam and electric railway purposes, introduced extensively within the last year by the John W. Cloud Co. and the McGuire Manufacturing Co. A. S.

1003. *Gas-driven Electric Light Station.* (Lightning, 13. pp. 162–163, 1898.)—The novel feature in this installation is the high-speed vertical gas-engine coupled direct to dynamos supplying 600 amperes at 110 volts for glow-lamps and Jandus arcs without fluctuation in the light. Three combined sets of engines and dynamos stand within a floor-space of 13 feet 6 inches by 8 feet. There is given a photograph of an engine-house, and a drawing showing the working parts of the gas-engine in section. The gas-engine has no valves, and the explosions take place inside the hollow piston. The connecting-rod is double, one rod revolving about the other and rotating the piston in the cylinder through 360 degrees once every two strokes. This combined rotary and reciprocating motion brings the two holes in the piston opposite the admission and exhaust ports, besides distributing the lubrication well and causing even wear of the piston. The engine speed is 560 revolutions per minute ; so that there are about 280 explosions per minute. Two 3-feet flywheels, each weighing 5 cwt., with an adjustable 'hit-or-miss' governor, suffice to keep the velocity constant within the desired limits. There are also two batteries of E.P.S. accumulators to take the night and Sunday loads, and to guard against stoppage by the bursting of an ignition-tube. The maximum charge is 6*d.* a unit, and 'reduction on taking a quantity.'

W. R.

1004. *Enclosed Arc Lamps.* **J. H. Hallberg.** (Elect. Rev. N.Y. 32. p. 296, 1898.)—This paper gives some practical details as to the cleaning and trimming of these lamps, including a method of removing deposits from the inner globes. C. K. F.

1005. *Davy Arc Lamp Hoisting Gear.* (Electrician, 41. pp. 176–177, 1898.)—This gear provides for isolating the lamp from the circuit when it is lowered for trimming, and also for obviating the necessity of opening the door of the post-chamber. The lamp is provided, at the top of the casing, with insulated contact-rings which, when the lamp is raised, engage with spring-contacts arranged in a hood on the post-bracket. Special pawls and a ratchet-wheel are provided for locking the winch for the steel suspension rope, so that the winch-barrel is released when the key is in position. A number of clear detail drawings and a photograph of the gear are given in the original paper. C. K. F.

1006. *Incandescent Lamp Efficiency.* **F. W. Willcox.** (Elect. World, 31. pp. 582–583, 1898.)—A paper very similar to that referred to in Abstract No. 224. A. H.

TELEGRAPHY AND TELEPHONY.

1007. *Cable Relay.* **K. Gulstad.** (Elect. Rev. 42. pp. 751–754, 1898.)—By a special arrangement of condensers and connections, it is proposed to convert any polarised double-current relay into a relay for cable signals. The usual source of insensitiveness is in the magnetic attraction between the armature, or tongue, and the nearest pole-piece. This attraction can be done away with, and converted into a repulsion, by arranging the relay as an interrupter, so that the tongue vibrates at a certain rate between the contacts, *i. e.* the rate at which it is agreed to signal Morse 'dots.' As the result of experiment, the author has discovered the best method of 'tuning' the vibrator by the addition of condensers and resistances. It is found that for a given arrangement of condensers etc., the tongue is able to vibrate at one or other of two different rates; but the vibrations are stable for one condition only. When a marking current from the cable enters the relay it stops the vibrations of the tongue and holds it over against the contact-stop.

[The article is to be continued.] R. A.

1008. *Acoustic Telegraphy.* **E. Hardy.** (Comptes Rendus, 126. pp. 1496–1497, 1898.)—The paper describes a microphone adapted for submarine transmissions. A little disc of carbon is fixed at the centre of a vibrating plate. Rods (forming pivots) of carbon, with counterpoises to regulate the pressure, are placed round the disc, a small quantity of mercury surrounding each pivot ensuring electrical contact. A. Gs.

1009. *Hertz Telegraphy.* **W. J. Clarke.** (Amer. Instit. Elect. Engin. 15. pp. 61–67, 1898; and Elect. Engin. N.Y. 25. pp. 391–393, 1898.)—These two papers describe the apparatus used by the author to demonstrate the system of telegraphy by Hertz waves. The apparatus, consisting of transmitters, coherers, and relays, has few points of novelty. Figures are given of instruments and connections. R. A.

1010. *Inductive Disturbances in Telephones.* **F. Laarmann.** (Elekt. Runds. 15. p. 132, 1898.)—The inductive disturbances in telephone circuits, due to variations of current in neighbouring electric-light mains, and to other causes, may be to some extent compensated by a method recently patented by Brockelt in Dresden. The primary of an induction-coil is placed in series with the telephone line-circuit; and the secondary of the same coil is connected as a shunt between two points in that circuit, so that the secondary currents oppose and neutralise the primaries.

Telephones are connected either two in series or two in parallel in the shunted portion of the line. Or another induction-coil may be inserted in the shunted portion; the primary being to line, and the secondary to the receivers. Experiment shows that by properly arranging the apparatus the telephone current is only slightly weakened by this device; very little alteration is required to apply it to existing systems, and it is claimed to be very effective. R. A.

1011. *Private Telephone Switchboards.* **Mandroux.** (Électricien, 15. pp. 136–139, 1898.)—A subscriber can call several others in conference, and conversations can be kept secret from the local operator (of the private installation) by Mors method now working five years at Mm. Meniers on the monocord principle. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

SEPTEMBER 1898.

GENERAL PHYSICS.

1012. *Energy Losses in Torsion Phenomena.* **H. Bouasse.** (Annal. Chim. Phys. 14. pp. 106–144, 1898.)—Reference is made to a previous paper which appeared in the same journal (see Phys. Soc. Abstracts, No. 643, 1897), and to papers published in the 'Ann. de la Faculté des Sciences de Toulouse,' 1897, 1898. A huge Deprez-D'Arsonval galvanometer was not found suitable for producing sinusoidal alternating torsion in a platinum wire 10 m. long. In the mechanical arrangement adopted, a vertical steel pin carries two pulleys, to which two fine threads are attached. The one thread is of rubber; to its extremity circular motion is imparted by means of a small dynamo and several sets of gearing. An improved dynamometer has been used for measuring the couples. The steel pin described sinusoidal rotations, varying in amplitude between 0° and 400°, and in period between 30 sec. and 1 hour. The researches are not yet completed. H. B.

1013. *Osmose of Liquids through Vulcanised Caoutchouc.* **G. Flusin.** (Comptes Rendus, 126. pp. 1497–1500, 1898.)—The caoutchouc is in the form of sheets 1 mm. thick. Its density at 17° is 0·997; it gives 2 % of ash, and contains 12·54 % of sulphur, of which only 1·28 is combined. Placed in the liquids indicated below, it swells and becomes translucent, but preserves its cohesion. The caoutchouc is placed between two perforated discs of sheet-iron. The compound disc, thus produced, divides a vessel into two compartments. In one compartment is placed ethyl alcohol, and in the other the liquid the behaviour of which is to be studied.

To measure the osmotic flow a horizontal tube is attached to each compartment, the rate of flow being indicated by the change in position of the meniscus. In the cases considered the flow always takes place towards the alcohol. Taking the flow of carbon disulphide as 193·8, that of chloroform is 145·3; toluene, 76·0;

ether, 76·0; benzene, 57·0; xylene, 50·3; essence of petroleum, 47·5; benzyl chloride, 13·3; essence of turpentine, 11·4; petroleum oil, 8·5; nitro-benzene, 2·8.

With the object of indicating the cause of the flow the author determines the rate at which a disc of caoutchouc increases in weight when placed in the various liquids. In each case the rate is a maximum at or near the beginning, and diminishes with increase of the time. The experiments show that the rates of osmotic flow are in the same order as the *initial* rates of increase in weight. A. Gs.

1014. *Stress-Strain Relations of Rubber.* **R. H. Thurston.** (Science, 7. pp. 522–523, 1898.)—The author refers to some earlier work, and then says:—"In all cases the substance behaved under load precisely as do other materials in the early part of its strain; then a reversed curve is described, and the test-piece stiffens greatly, and offers continually increasing resistance until at last rupture takes place, without yelding by inelastic deformation at any point of its course. Toward the end of its test the substance yields proportionately to the applied load. The fracture is sharp and without warning, and the break clean and smooth and at right angles to the line of pull. No permanent reduction of section is observable after fracture. The reduced section immediately before breaking is but one-eighth the initial section of the unstrained rubber. Permanent set occurs to an exceedingly slight extent, and its value is dependent upon the maximum load and independent of the elastic properties of the substance. The set of the material would not be noticed in ordinary use. Permanent loads produce permanent continuous extension and in time fracture. This was found to be true for loads rising from 40 to 330 pounds per square inch (2·8 to 23·18 kgs. per sq. cm.), and stress-strain diagrams for two weeks showed steady elongation.

"Plotting curves having for their coordinates loads per unit of area and areas of section of test-piece at point of maximum reduction, the stress-strain diagram thus produced becomes altered in form and similar to those of other materials plotted in the usual manner. It has the same curvature at the initial stage, the same straight line to an (apparent) elastic limit, and finally a steady but slight rise with increasing loads with a sudden break at the end. The highest load measured in these experiments was 810 pounds per square inch (56·7 kgs. per sq. cm.). *The quality employed* in all cases was that of the *stationer's elastic bands.*"

The author concludes with a reference to R. A. Fessenden's explanation of the observed phenomena. A. Gs.

1015. *Interferential Calibration of Screws.* **M. Hamy.** (Comptes Rendus, 126. pp. 1772–1774, 1898.)—The author gives a complete account of a somewhat novel method of accurately calibrating the screw of a micrometer or dividing engine. The

method of working out the observations of the interference-fringes is somewhat similar to that employed by Michelson in his work on the value of a metre in light waves, but the apparatus with which the interference is produced is different. A plane mirror, thickly silvered, is placed on the carriage of the micrometer, and opposite to it, but attached to the micrometer-screw, is placed a lens of very slight curvature, the side nearest the plane mirror being half-silvered. The system is illuminated by monochromatic light from a small aperture placed at the focal plane of the lens, the eye being placed at the reflected image of the aperture. Interference-fringes in the form of circles (if glasses be well figured) are seen, and these are varied by turning the micrometer-screw through known distances. From the variation in the number of bands produced, the exact amount by which the lens is advanced or withdrawn with respect to the mirror can be determined, and this then gives a direct comparison of the value of the screw at those positions.

C. P. B.

1016. *Optical Measurements of Length.* **A. Perot** and **Ch. Fabry.** (Comptes Rendus, 126. pp. 1779–1782, 1898.)—The authors describe the continued application of their method of utilising interference-fringes produced between two lightly silvered glass plates. By having a standard pair of plates which have been accurately calibrated, the fringes produced by them can be matched with those produced in another system the distance between which may be some multiple of the standard. They have measured in this way the thickness of a glass cube of 3 cm. side, and hope to apply it to lengths up to 1 metre. C. P. B.

1017. *Compensated Interference Dilatometer.* **A. E. Tutton.** (Roy. Soc. Proc. 63. pp. 208–211, 1898.)—The author describes a form of Fizeau interference dilatometer, which he considers combines the best features of the apparatus described by Benoit and that described by Pulfrich. Besides other improvements, a new principle of compensating for the expansion of the screws of the Fizeau tripod, which supports the object, is introduced, which enhances the sensitiveness of the method so highly as to render it applicable to the determination of the expansion of crystals when only a block of 5 mm. thickness can be procured. The principle of the compensation depends on the fact that aluminium expands 2·6 times as much as platinum-iridium for the same increment of temperature. The author employs a tripod of platinum-iridium, and places upon its transverse table, through which pass the three screws, a disc of aluminium whose thickness is 1/2·6ths of the length of the screws. The space between the lower surface of the glass plate which is laid upon the upper ends of the screws to assist in producing the interference, and the upper surface of the aluminium then remains constant for all temperatures under observation; and if a crystal is laid upon the aluminium compensator,

the whole amount of its expansion is available for measurement by the interference method. Hence the method is no longer a relative one, but affords direct absolute measurements of the expansion of the substance investigated. The paper contains a further description of the rest of the expansion apparatus and its mounting, also of the illuminating and observing apparatus. E. C. R.

1018. *Slow Gaseous Diffusion in High Vacua.* **E. Merritt.** (Phys. Rev. 6. pp. 167–169, 1898.)—In high vacua, equalisation of pressure is very slow (Crookes). A lecture-experiment, exaggerating this result, is obtained by exhausting two vacuum-tubes connected by a long capillary tube, so that the molecules from the second tube must, during exhaustion, flow into the first through the capillary tube. The vacua in the two tubes are very different, as shown by the character of discharges through them, when the exhaustion goes beyond 3 or 4 mm. The one may show kathode-rays or fluorescence, while the other still shows an ordinary Geissler discharge. In time they equalise. Curious results arise by varying the connections. A. D.

1019. *Measurement of Small Gaseous Pressures.* **C. F. Brush.** (Science, 7. pp. 730–734, 1898.)—This is a description of a modification of the McLeod vacuum-gauge. The author makes the two tubes in which the mercury rises and whose difference of level is measured of much larger diameter than usual (about 20 mm.), they are made from contiguous parts of the same piece of tubing. The one in which the residual gas is compressed, or the gauge-head, is closed at its upper end by a piece of heavy tubing, which will just slip inside it with the least possible clearance. One end of this piece of tubing is first closed as squarely as possible by fusion, and then ground to a convex spherical surface of a long radius; the tube is then slipped into the gauge-head closed end downwards, and the open ends of the two tubes fused together.

The paper gives details of finding the capacity of the gauge-head, etc., and observing the difference in the levels of the columns by means of a very elaborate cathetometer. The author claims that small pressures can be measured by this apparatus with a probable error of less than a thousandth part of a millionth of an atmosphere. E. C. R.

1020. *Velocity of Earthquake Waves.* **G. Agamennone.** (Roma, R. Accad. Lincei, Atti, 7, pp. 67–73 & 162–166, 1898.)—The author calculates that the velocities of the *initial* disturbances on Aug. 19th, 1895, from Aidin to Padua and Strasburg were respectively 9800 and 3100 metres per second; whilst the velocities of the maximum disturbances were 3200 and 2500 respectively. In the case of the Pergamos earthquake on Nov. 13th–14th, 1895, the velocities from Pergamos to Padua and Nicolaiew were 4500 and 3500 metres per second respectively. He places no great faith in the data on which the calculations are based. A. Gs.

1021. *Velocity of Earthquake Waves.* **G. Agamennone.** (Roma, R Accad. Lincei, Atti, 7. pp. 265–272, 1898.)—A velocity of 8·3 or 10·6 kilometres per second is obtained for the wave-front of the Indian earthquake of June 12, 1897, the two values being obtained by means of the two times recorded for the start of the earthquake at Calcutta. The velocity of the propagation of the maximum inclination of the earth's surface to the vertical comes out 2·61 or 2·76 kilometres per second. W. W.

1022. *Solar and Lunar Influence on Atmosphere.* **A. Poincaré.** (Comptes Rendus, 126. pp. 1269–1272, 1898.)—The author gives an example of the application of the formula derived in a previous paper for expressing the relations between the solar and lunar attractions and the terrestrial atmospheric pressures. C. P. B.

1023. *Enlargement of Sun at Horizon.* **D. Eginitis.** (Comptes Rendus, 126. pp. 1326–1329, 1898.)—The paper is a *résumé* of the various theories which have from time to time been put forward to account for the apparent enlargement of the discs of the sun and moon at the horizon. The author concludes that, although several of the explanations put forward may have some influence on the phenomenon, the principal determinant of its appearance is yet unknown. C. P. B.

1024. *Wind Pressure and the Moon.* **A. Poincaré.** (Comptes Rendus, 126. pp. 1449-1451, 1898.)—The author discusses the application of the formulæ previously derived (see Comptes Rendus, 126. pp. 1054–5, 1898) for the expression of the attraction between two bodies to the attraction produced between the moon and the earth's atmosphere. Special reference is made to the formation of the polar vortices, and to the effect of harmonic periods in the lunar attraction. C. P. B.

1025. *Planetary Atmospheres.* **G. Johnstone Stoney.** (Ast. Phys. Journ. 7. pp. 25–55, 1898.)—This paper is a reprint from vol. vi. p. 305 of the 'Transactions of the Royal Dublin Society,' and extends that application of the Kinetic Theory of Gas to the investigation of the phenomena of atmospheres which the author had employed in a paper on the "Physical Constitution of the Sun and Stars," published in the 'Proceedings of the Royal Society' for 1868.

In the earlier paper the conditions which limit the height of an atmosphere were investigated, and it was shown that when an atmosphere consists of a mixture of gases, the elevations to which the constituents will range stand in the order of their densities; from which it follows that Dalton's law of the equal diffusion of gases does not extend to the upper regions of an atmosphere.

The inquiry of the present paper is with reference to the conditions which determine whether a gas can be retained by the atmosphere of a celestial body, or will escape from it; and it is shown that the issue depends on the following physical circumstances:—(1st) On the amount of the planet's potential of gravitation at the outskirts of its atmosphere; (2nd) on the tangential speed of the top of the atmosphere over the equator consequent upon the planet's rotation; (3rd) on the speed and direction of the wind in the same situation; (4th) on the greatest speed which can with sufficient frequency be attained by the molecules of the gas at a given temperature and when quiescent, *i. e.*, when there is no wind or other current in the gas; (5th) on the highest temperature of the gas in the upper regions of the atmosphere; and (6th) on the intensity of sunshine upon the gas in the planet's atmosphere, which depends upon absorption in the solar atmosphere, and varies from one gas to another.

Basing his investigation upon these principles, the author explains the absence of hydrogen and helium from the earth's atmosphere, and the absence of all known constituents of an atmosphere from the moon, by showing that in accordance with the Kinetic Theory these gases are so circumstanced upon the earth and moon that their molecules can drift away; and he further arrives at the conclusion that water cannot be a constituent of the atmospheres of either Mercury or Mars.

The conditions which prevail upon Mars are specially discussed. In the absence of water, it is suggested that nitrogen, argon, and carbon dioxide are the most probable constituents of its atmosphere. The most condensible of these is carbon dioxide, and to it are referred the snow-caps which are formed alternately on the north and south poles of Mars. Carbon dioxide would be the heaviest constituent of such an atmosphere, and would behave differently to water in the earth's atmosphere, of which the vapour of water is its lightest constituent. It is inferred that the vapour upon Mars cannot produce clouds floating at a distance above the solid surface of the planet, as water does in the earth's atmosphere; but only low-lying fogs with frost and snow. To these and to the vapour being distilled towards the two poles alternately, are referred the varying but frequently recurring appearances which observers have recorded upon that planet.

From the circumstances that helium escapes from the earth's atmosphere, and that water does not escape from Venus, it is inferred that the molecules of a gas sufficiently often attain a velocity which is 9 times the velocity of mean square, to produce marked effects in nature, but that a velocity of 18 times the velocity of mean square is a very infrequent physical event.

The investigation also offers an explanation of the gaps in the series of chemical elements which upon the earth seem to exist between hydrogen and helium, and between helium and lithium. It shows that if the suspected intermediate elements exist anywhere upon the earth, it can only be in the form of compounds or

as occluded gas; whereas, the conditions upon Jupiter are such that they may all be constituents of his atmosphere, and that some of them may be present in the atmospheres of the three other giant planets of the solar system, though necessarily absent from the atmospheres of the group of four smaller inner planets to which the earth belongs.

By an application of the same method of investigation to the satellites and minor planets of the solar system, it is ascertained that there can be no atmosphere upon any of these bodies, except, perhaps, on the satellite of Neptune; and with reference to the Sun, it is shown that the greatest size which the sun can have had since it became a globe—that is, the greatest which is compatible with its atmosphere having then, as now, contained free hydrogen—is an immense sphere extending out to between where the orbits of Mars and Jupiter now lie; so that from some such immense size as this it may have been since slowly contracting.

Finally, the investigation leads to the conclusion that the molecules of the gases which have from time to time escaped from planets and satellites have but seldom been able to extricate themselves altogether from the solar system; and that accordingly the vast majority of them are now circulating in countless numbers round the sun, like excessively minute independent planets.

AUTHOR.

1026. *Latitude Variation in a Rigid Earth.* **H. Crew.** (Phys. Rev. 6. pp. 153–163, 1898.)—The writer explains how, treating the earth as a rigid body approximately spherical, if it were originally set spinning about an axis not exactly coinciding with the axis of figure, *i. e.* of greatest moment of inertia, the axis of figure would describe a small cone about the invariable axis; and therefore the latitude of any place on the earth's surface, meaning thereby the angle between the plumb-line and the invariable axis, would vary periodically. The period is calculated at approximately 306 days.

A note is added on the adjustment of Maxwell's top. S. H. B.

LIGHT.

1027. *Instrumental Aberrations and Astronomical Diffraction.* **K. Strehl.** (Zeitschr. Instrumentenk. 17. pp. 301–314, 1897.) —Formulæ and tables are given relating to spherical aberration, astigmatism, and chromatic aberration. In obtaining them the author has started with the assumption of a spherical wave interrupted by geometrically circular boundaries, regarding everything else as a modification of the first order. Thus, to a first approximation, his results are confirmed by Lommel's discussion of diffraction through a circular aperture. The general conclusion is that spherical aberration and astigmatism can be reduced to amounts which are practically unimportant; chromatic aberration is the most troublesome defect, but can be partially overcome by increase of focal length. Objectives intended for photographic work should be corrected for those rays which are most active chemically for the object in view; the adjustment of the instrument may be effected by the use of auxiliary glasses.

The author proceeds to discuss the influence of diffraction on observations of such phenomena as a transit of Venus or an eclipse of a satellite of Jupiter. The conclusion is that, with the usual instruments, these phenomena are sensibly the same as they would be according to the geometrical theory. G. B. M.

1028. *Improved Form of Abbe Refractometer.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 18. pp. 107–116, 1898.)—The improvements consist in:—(1) grinding one face of the lower prism to a matt surface, instead of polishing it; (2) removing the small illuminating prism and grinding matt the surface to which it was cemented; (3) providing the case of the upper prism with a metal flap, by adjusting which the instrument is quickly adapted for the three different methods of observation. Descriptions, with figures, are given of the complete instrument with and without heating-apparatus, of a special form for technical purposes and of a special pattern for educational purposes. All these are supplied by Zeiss of Jena. G. B. M.

1029. *Vierordt's Symmetrical Double Slit.* **C. Leiss.** (Zeitschr. Instrumentenk. 18. pp. 116–117, 1898.)—The advantages claimed for the form here described are lightness and trustworthiness in the arrangements for estimating the width of the slit. Price 135 *m.* (R. Fuess, Steglitz bei Berlin.) G. B. M.

1030. *Relative Retardation in the Components of Light in a Crystalline Plate.* **J. Walker.** (Roy. Soc. Proc. 63. pp. 79–90,

1898.)—If the surface of the plate be the plane of xy, the positive axis of z being directed inwards, the relative retardation is $T(n_1-n_2)$, where the velocity of light in air is unity, T is the thickness of the plate, and $n_1 n_2$ are the positive roots of a biquadratic in n obtained by expressing that $lx+my+nz=1$ is a tangent-plane to the wave-surface. The coefficients of the biquadratic are linear functions of $\sin i$, whence writing the roots of the equation as series proceeding by powers of $\sin i$ and expressing the coefficients as symmetrical functions of the roots, the terms of the series may in general be determined in succession by means of linear equations.

This method does not apply when the plate is perpendicular to an optic axis of a biaxal crystal. In this case the biquadratic may be written in the form

$$n^4+(c_0+c_2\sin^2 i)n^2+b_3\sin^3 i\,.\,n+a_0+a_2\sin^2 i+a_4\sin^4 i=0\,;$$

and neglecting the coefficient of n the roots are

$$\pm(\pi+\rho),\qquad \pm(\pi-\rho),$$

where π, ρ are series proceeding by even and odd powers of $\sin i$ respectively. Assuming, then, that the actual roots are

$$\pi+\rho+\alpha,\qquad -\pi-\rho+\beta,\qquad \ldots\,.\,,$$

the successive terms of the series α, β, γ, δ may be calculated by the former method. The calculation is carried as far as terms of the fourth order, and may easily be extended. AUTHOR.

1031. *Radiation in a Magnetic Field.* **A. A. Michelson.** (Phil. Mag. 45. pp. 348–356, 1898.)—In a former paper (see Abstract No. 22) the author gave particulars of a preliminary examination of the effect of a magnetic field on the spectral lines of various substances. In the present paper he states that the phenomena, when more completely observed, are more complex than was suspected previously. The separate lines produced by the magnetisation are themselves found to be multiple. The following summary of the relations determined are given :—

(1) All spectral lines are *tripled* when the radiations emanate in a magnetic field.

(2) The separation is proportional to the strength of field, and is approximately the same for all colours and for all substances.

(3) Viewed in a plane perpendicular to the magnetic field, the outer lines are polarised parallel to the field and the central line is polarised at right angles to the field.

(4) Viewed in a direction parallel to the magnetic field, the central line *vanishes*, while the outer ones are *circularly* polarised—the shorter waves in the direction of the magnetising current, and the longer waves in the opposite sense.

(5) The " middle line " (of the original triplet) is a symmetrical

triple, the distance between the components being one-fourth that of the "outer line," and therefore also proportional to the strength of field.

(6) The relative intensity of the components varies for different substances and for different lines of the same substance; and accordingly the group may appear as a single line or a double or a triple.

(7) The "outer lines" are unsymmetrical, but are symmetrically placed with respect to the "middle line." The distance between the components is usually one-fourth that between the "outer lines," but in some cases one-sixth.

(8) The *intensity* of the components varies for different spectral lines, and these variations do not always correspond with those of the "central line." The outer groups may accordingly appear as single, double, or multiple lines.

In general it was found that the spectral lines examined could be divided into three types, the visibility-curves of which had decided and distinct peculiarities. The chief factor determining the type to which a line belongs consists in the number of secondary components into which the line of the original triplet can be resolved.

The above phenomena are based on an examination of the eight substances, Mercury, Cadmium, Zinc, Sodium, Thallium, Lithium, Hydrogen, and Helium; and the author mentions that it is possible that the laws enunciated in the paper may have to be modified as the work extends. C. P. B.

1032. *Radiation Phenomena in a Strong Magnetic Field.* **T. Preston.** (Dublin Soc. Trans. 6. pp. 385–391, 1898.)—The author gives a general account of the effects of a strong magnetic field on the spectral lines of a spark source of light placed in it. The paper is illustrated by a plate reproduced from photographs of the spectral lines as modified by the magnetic field. These photographs show the lines 4680 of Zinc and 4678 of Cadmium as resolved into pure triplets, while the lines 4800 of Cadmium and 4722 of Zinc appear as quartets. These and other phenomena are discussed in the paper. (See further, Abstract No. 755.)

AUTHOR.

1033. *Uranium Rays and Condensation of Water Vapour.* **C. T. R. Wilson.** (Cambridge Phil. Soc. Proc. 9. 7. pp. 333–338, 1898.)—Uranium rays produce in moist air which they traverse nuclei on which condensation takes place if a certain degree of supersaturation be exceeded. To produce this degree of supersaturation sudden expansion is necessary, such that the ratio of the final to the initial volume of the air is equal to 1·25—the same limit as was found in similar experiments with Röntgen rays described in a former paper (Phil. Trans. vol. 189. A. 1897, p. 265). Thus nuclei of the same kind are introduced by Röntgen rays and

uranium rays; the view is taken that they are identical with the ions to which the conducting-power of the gas under the same conditions is due. AUTHOR.

1034. *Röntgen Rays.* **W. C. Röntgen.** (Annal. Phys. Chem. 64. 1. pp. 18–37, 1898.)—If an opaque plate be arranged between the vacuum-tube and a platinocyanide-barium screen, even pretty close to it, there is some fluorescence, which is cut off when the air situated laterally is sheltered from the impact of Röntgen rays by a thickness of lead. The effect is not due to the bending of rays; but the air, when struck by the rays, sends out Röntgen rays in all directions: so that if our eyes were sensitive to these rays, a vacuum-tube would appear like a lamp in a room filled with tobacco-smoke, and possibly the light from the tube and that from the air would have different colours, though there is at present no means of testing this question (whether the air acts by simple diffused reflection or as a *quasi*-fluorescent substance), for the rays from the air are also photographically active.—For comparative measurements the author uses a simple vertical plate of lead along the mid-line of a table; the fluorescent screen is placed at right angles to this, so that half the screen looks towards the left and half towards the right side of this partition. The two tubes to be compared are placed one on each side of this partition, and each then affects only one half of the screen. In using this it is found that the tubes are very inconstant: they are sensitive to irregularities in the make-and-break (worse with Foucault's than with Deprez' contact-breaker); and when the outbursts of Röntgen radiation follow one another so rapidly that the eye cannot detect any want of continuity in the phosphorescence on the screen, the brightness of the screen depends on the intensity of the radiation from the platinum plate of the discharge-tube, on the kind of rays reaching the screen, on the distance between the screen and the tube, on the absorption undergone by the rays before reaching the screen, on the number of discharges per second, on the phosphorescent afterglow of the screen, and on the radiation to the screen from surrounding objects.—From a flat plate the radiation is equal in all directions up to about 80° from the normal, and the difference is only well-marked at between 89° and 90°. The mode of experiment consisted in flexible photographic films bent to a half-circle half surrounding the source; there is no ascertainable difference between the radiations at different angles; the photographic effect increases, except in extreme cases, with the angle between the source of rays and the photographic plate. There is an analogous case of equality in all directions in optical fluorescence: drop fluorescein into water in a square tank illuminated by white or violet light, and the walls of the columns of fluorescein solution appear the brightest, *i.e.*, where the angle of emanation of the phosphorescence-light is the greatest. Stokes has explained this through the fluorescence-light being much less absorbed by the fluorescein-solution than the exciting rays are. So

here, the exciting kathode-rays are much more absorbed by platinum than the induced Röntgen rays. The sharpest shadows are obtained by tilting the platinum away from parallelism with the photographic plate through not more than 80°; and the impression is then the most intense.—In the absence of disturbing-effect from the air, and on condition that the radiations remain of the same kind, the brightness of a fluorescent screen varies inversely as the square of its distance from the source. Splitting a solid into layers makes no difference in its transparency; nor does putting it nearer to or farther from the screen. Rays which have traversed one thickness traverse another more readily (in proportion); so that the specific permeability (fraction of radiation let through a layer of unit thickness) is greater, the thicker the object. When two plates of different substances are equally permeable, this equality disappears if the plates are equally thickened or thinned; with plates of Pt 0·0026 mm. and of Al 0·0299 mm. thick, one Pt = six Al; but two Pt = sixteen Al. Other similar numbers are given for other tubes. The relations between the equivalent thicknesses of two substances vary with the thickness and the nature of the material (*e. g.*, the walls of the vacuum-tube) traversed by the rays before reaching the screen. The author uses a platinum-foil, 0·0026 mm. thick, with 15 holes in it, closed respectively by single, double, . . . 15-fold thicknesses of aluminium, each of 0·0299 mm. thickness. When this is interposed, a glance shows which thickness of aluminium is equal to 0·0026 mm. of platinum. The corresponding number of aluminium thicknesses is called the "window-number," the apparatus being called a "platinum-window." Example: With direct radiations the window-number was 5; on interposing 2 mm. soda-glass, the window-number became 10; the rays filtered through the glass found it relatively easier than before to traverse the aluminium. Rays sent through this platinum-window and then through a dozen photographic films indicated the window-number 10 for the first film and 13 for the last.

Conversely, one and the same substance is differently permeable to rays from different tubes: lowest vacua, least potential of discharge, "softest" tubes, least power of penetration; highest vacua, highest potential of discharge; "hardest" tubes, greatest power of penetration. With the former, window-number say 2; with the latter, may be beyond 15. With the former, simple shadows of the hand; with intermediate exhaustions, good bone-shadows; with the last, bones also permeable.—With one and the same tube the quality and penetrating power of the rays depends upon the action of the contact-breaker (which fluctuates), the length of spark-gap parallel to the tube in the secondary circuit, the introduction of a Tesla transformer, the amount of vacuum, and other uninvestigated changes within the tube itself. Putting a tube on the pump at the lowest sufficient vacuum, with small spark-gap parallel to the tube, the tube is very "soft," the rays absorbable, and the window-number small. Putting in a Tesla transformer, or a spark-gap in series, the tube is "hardened."—With a Tesla

transformer in circuit, with narrow tube and wire electrodes, the rays are given off in air at 3·1 mm. Hg, and at still lower vacua in hydrogen. The highest vacuum under which the rays can be given off is beyond 0·0002 mm. Hg.—As the vacuum is increased, the spark-gap must be at the same time lengthened; and when the tube is so "hard" that the spark-gap has to be more than 20 cm. long, the rays will go through 4 cm. of iron. The tube will also become harder through its own continued action: so "hard" that a shadow-photograph of a gunlock at 15 cm. distance can be taken in 12 minutes—a relatively long exposure, because the rays go through the photographic film instead of affecting it. This hardening is due to self-exhaustion, and to some change in the electrodes themselves. A tube, if too hard, can be softened by letting in air, by warming it, by reversing the discharges, or by driving very powerful discharges through it. In the last case, the necessary potential of discharge becomes high, but the rays are very absorbable and the window-numbers low. It appears that the kind of rays emitted depends on the mode of discharge, however this may be attained: the same mode of discharge would give the same Röntgen rays, even at relatively high pressures. The quality of the rays is not affected by the strength of the primary current, assuming that the contact-breaker acts equally at all current-strengths; but their intensity is affected. Therefore (1) the radiations from a tube are mixed, and differ in absorbability and intensity; (2) the composition of the mixture depends on the mode of discharge; (3) different rays are absorbed by different substances; (4) kathode rays resemble Röntgen rays in many respects, and the two discrepancies (*a*) difference of absorbability, and (*b*) the permeability to the two kinds of rays according to the density of the substance not following the same law, may be found bridged over by further researches leading to the discovery of rays of intermediate condition, say the Röntgen rays in ultra-soft tubes and extremely thin windows, or the kathode rays in ultra-hard tubes.

Photographic results follow the fluorescent screen pretty closely, particularly with soft tubes; but with hard tubes the window-number seemed a little lower than with the screen. When a hard and a soft tube bring the two halves of the fluorescent screen to the same brightness, a photographic plate put in place of the screen is less affected by the rays from the hard tube: in the latter the rays go through the film, and will go through 96 films and impress the last one while the first is scarcely over-exposed. For this special reason, hard tubes require longer exposures; very soft tubes need longer exposures on account of their feebler intensity.

In a tube in action, Röntgen rays come not only from a minute area on the antikathode but, more feebly, from the whole plate and a part of the walls of the tube. Kathode rays go in all directions from the kathode, but only feebly except along the axis. When the tube is hard and the platinum antikathode very thin, Röntgen rays start in considerable quantity from the back of the latter; and

in very hard tubes the point which most emits Röntgen rays can be shifted away from the antikathode by a magnet.

Continued experiments show no difference in the permeability of any crystal according to the direction of the axis. It is the case that the eye can sometimes perceive the presence of Röntgen rays: this is due to the setting up of fluorescence in the retina; and with hard tubes, looked at through a narrow slit in a lead sheet, it is not difficult, by moving the slit, to get changing luminous figures.—Nothing which may really be referred to diffraction has been discovered, though repeatedly sought for; apparent instances have all been found to be otherwise explicable. A. D.

1035. *Recovery of Röntgen-Ray Tubes.* **V. Machado.** (Comptes Rendus, 126. p. 1341, 1898.)—The tube surrounding the stem of the kathode is wrapped in a flexible metallic sheet of tin, lead, or platinum, or surrounded by an insulated coil of copper wire. With this arrangement, exhausted tubes recover in a few seconds. E. E. F.

1036. *Diffusion in Photographic Development.* **A. Guébhard.** (Comptes Rendus, 126. pp. 1341–1344, 1898.)—When a portion of the developer is divided off from the rest by an inverted watch-glass or similar means, osmotic currents set in across the capillary boundary, tracing dark lines on the plate. The currents always travel from the darker to the lighter portions. The traces are bounded by a brighter ring, where apparently the currents are stopped in their progress and escape upwards in vortices. Colson's "confined-development" effects are probably due to the unequal swelling of the gelatine, and "silhouetting" is most likely an effect of irradiation. E. E. F.

1037. *Lippmann Photographs.* **R. Neuhauss.** (Annal. Phys. Chem. 65. 1. pp. 164–172, 1898.)—The author has succeeded in directly viewing and photographing the fine lamellæ produced in a Lippmann photograph by rays of red light, the intervals between which are of the size of the wave-length of that colour. The sections are obtained by means of a microtome, and are embedded in canada balsam. The magnification used is 4000. Some seven or eight layers are clearly shown on the photographs. The attainment of this result, although difficult, is not very extraordinary in microscopic work. The layers of *Amphipleura pellucida* are 0·00024 mm. apart, while the wave-length of red light is 0·00038 mm. E. E. F.

HEAT.

1038. *Thermal Conductivity of Solid Salts.* **C. H. Lees.** (Mem. Manchester Lit. & Phil. Soc. 42. 5. pp. 1–4, 1898.)—The apparatus used, consisting of a fluid plate through which heat, generated electrically, could flow, and in which the temperature-gradient could be determined, is described in Phil. Trans. 1897. The salt to be measured was tried in fluids of different conductivities, mostly mixtures of alcohol and water, till its presence made no difference to the observed conduction in the fluid. The oxides and sulphides had values higher than water, up to 0·025 for emery-powder. KCl and NaCl gave 0·014, 0·013. Salts containing water of crystallisation mostly gave values near to that for water (0·0014). No important regularities were discovered.

R. A. L.

1039. *Calorimeter for the Human Body.* **W. Marcet.** *Heat evolved by the Human Body.* **W. Marcet** and **R. B. Floris.** (Roy. Soc. Proc. 63. pp. 232–242, 242–255, 1898.)—The apparatus is a large Berthelot calorimeter. A wooden chamber, covered outside with felt and inside with cotton-wool, contains a chamber of copper, carefully polished on the inside, 145 cm. high, 69 cm. wide, 810·4 litres capacity, weighing 62·37 kg. A rise of 1° C. in the temperature of the mass of copper would represent 5832 gramme-calories. The annular space between the two chambers has a breadth of 5 cm. The chambers are closed by a movable panel and a door, manipulated with the help of a tackle. Two fans, one fixed low down in the chamber, the other high up, drive the constantly circulating air through the tin vessel containing the ice, suspended from the ceiling of the chamber; the whole of the air of the chamber is carried through the calorimeter in about two minutes. The thermometers are divided into fiftieths of a degree. As a human body gives out about 90,000 calories during one hour (duration of one experiment), a rise of 1° C. in the temperature of the air in the chamber, amounting to 214 cal., is not of much consequence. The heating of the mass of copper is more to be feared; but the temperature of the copper could easily be maintained within 0°·3. The heating of the revolving-fan bearings proved insignificant; the heat generated by the friction of the blades against the air was determined by special experiments: it amounted to about 6000 cal. for 200,000 revolutions of the fans, which were driven by electric motors, and made together from 1000 to 3000 revolutions per hour. Determinations of the heat lost in the chamber by a 6-litre jar filled with hot water differed by 8 per cent., because the vessel could not be placed in position and taken out again with sufficient rapidity, and for other reasons. The burning of a jet of hydrogen in the chamber gave more concordant results

the mean found is 34428 cal. per gramme of H (34462 Favre and Silbermann).

The chamber seems well suited for its purpose, as the subjects could spend an hour in it without experiencing any discomfort. The subject sitting on a stool close to the calorimeter felt neither draught nor perspiration nor want of air. The sublingual temperature fell slightly, by about 0°·2 (0°·45 maximum); but the same falling was observed on sitting quietly in an ordinary room. 5 kg. of ice or more were cut into blocks of 2 or 3 inches diameter. The number of calories given out by one person varied for one subject (26 experiments) between 122,124 and 80,639 cal. per hour. Most of the tests were made after lunch; the influences of age, weight, a heavy meal, fasting, warm clothing, etc. have not yet been studied sufficiently. In a general sense it may be said that 4000 cals. are produced per gramme of oxygen absorbed. These are the means of 36 experiments with three different subjects. But the values varied between 3292 and 5031 for one person, and there is no proportionality. This want of proportionality may be due to a storage of oxygen in the tissues. In some cases fresh air was inspired through the nose and expired through the mouth, and carbonic dioxide determinations were made. The variations stated in this abstract are the largest observed, and concern one of the authors, age 69 years, weight 58 kg. H. B.

1040. *Latent Heat of Vaporisation.* **J. A. Groshans.** (Annal. Phys. Chem. 64. 4. pp. 778-788, 1898.)—[A] Assuming the gaseous laws to hold under one atmosphere at all temperatures, we have, with Regnault's value ·000089578 for the standard density of H, the volume of a gram-molecule of any normal vapour (*i. e.* at its absolute boiling-point T under one atmosphere) given by 81·7836 T c.cm. (see Abstract No. 66, p. 27): hence the specific volume s' of a normal vapour with molecular weight M is 81·78 T/M. [B] Trouton's law further gives $21{\cdot}139\,(T/M)\sqrt{a}$ for the latent heat λ of the normal vapour, where a is either 1 or 1·5. [C] The author has found a new law, viz. $NT/M = 27{\cdot}80178\sqrt{x}$, where N is the number of atoms in the molecule and x is a constant for each group of substances.

Taken in pairs, these laws give:—[AB] $s'/\lambda = 3{\cdot}86885\sqrt{a}$, or 1 calorie will vaporise so much of any liquid at its boiling-point under 1 atmo as will form $3{\cdot}87/\sqrt{a}$ c.cm. of vapour; [AC] $Ns' = 2274{\cdot}73\sqrt{x}$, or the volume of as many grams of a normal vapour as there are atoms in its molecule is $2275\sqrt{x}$ c.cm.; [BC] $N\lambda = 587{\cdot}702\sqrt{(ax)}$, or the heat required to vaporise as many grams of a liquid at its boiling-point under 1 atmo as there are atoms in its molecule is $588\sqrt{(ax)}$ calories. The values of λ calculated from [BC] agree very well with those obtained by experiment.

In many cases x is an integer: for water, ether, and a large group it is 5; for the propyl ether group 7, &c.; it is 3 for

$C_3H_6O_2$ and 6 for C_2H_6O, and increases by 1 for every CH_2 added. But for the ethers it is not integral, and for them therefore law [C] seems meaningless.

For ether, toluol, etc., $a=1$; it is 1·5 for water and the alcohols, etc.

[The notation here is quite altered, for the author writes *xsd* for x, *ldw*1*g* for λ, T*sd* for T, &c., and the numbers have been recalculated.] R. E. B.

1041. *Expansion on Vaporisation in Relation to Latent Heat.* **J. A. Groshans.** (Annal. Phys. Chem. 64. 4. pp. 789–793, 1898.)—In a former paper (with the notation of the last Abstract) it is asserted that $\rho x/N = y$ is obviously constant, where ρ is the density of liquid at its boiling-point under 1 atmo. Since the numbers given for y range from 1·6 for water to ·23 for ether, this statement must refer to groups if it has any validity. The expansion, being the ratio of the volumes of the vapour and the liquid from which it is formed, is $\rho s' = 2275\, y/\sqrt{x}$, and is thus the same for all substances with the same x and y. R. E. B.

1042. *Kinetic Theory of Liquids.* **W. Voigt.** (Göttingen Nachrichten, 1. pp. 19–47, 1897; 3. pp. 261–272, 1897.)—The first paper carries further the discussion begun in another memoir (see Phys. Soc. Abstracts, No. 646, 1897), in which two circumstances were purposely omitted from consideration, viz. (1) a possible polymerisation, and (2) a possible change of molecular intrinsic energy during condensation. Now the formula previously deduced for the latent heat, viz.

$$\lambda = \mathrm{BT}\{\log(\rho/\rho') + 1 - \rho'/\rho\},$$

suits the monatomic molecules of Hg very fairly well, but not the polyatomic and little polymerisable benzol at all, showing that in general (2) has greater influence than (1).

Liquids with monatomic molecules are then first considered; for these the above equation holds, which with Clapeyron's equation gives

$$\mathrm{T}(d\rho'/d\mathrm{T})(1/\rho' - 1/\rho) = \log(\rho/\rho');$$

this becomes

$$(d/d\mathrm{T})(\mathrm{T}\log\rho') = \log\rho$$

on neglect of $1/\rho$ in comparison with $1/\rho'$, and further gives

$$\mathrm{T}\log(\rho/\rho') = \text{const.}$$

on taking ρ const., which is equivalent to the constancy of $\frac{1}{2}c^2$, the gain of potential energy per unit mass on vaporisation. Hence is deducible a simple approximate expression for the difference between the saturation specific heats of the liquid and vapour; and expressions are also given for the pressure at a point in the liquid or gas at a distance from the surface

of separation. It is then shown that, if the viscosity-equation for gases holds for liquids too, $\eta/\eta' = R'^2/R^2$, where η denotes viscosity and R collision-distance; this gives for mercury $R'/R \doteq 4$, a result only explicable on the distant-action theory of collisions.

Liquids with polyatomic molecules are next investigated, and the assumption is made that the parts of the energy per unit mass of a liquid or gas which are changed by vaporisation or evaporation may be written $\frac{1}{2}k^2V^2$ or $\frac{1}{2}k'^2V'^2$, where k, k' are numerics that vary but slightly (if at all) with temperature. Then, proceeding as before, we find

$$k'\alpha' = k\alpha \equiv c/\delta \quad \text{and} \quad k'\rho' = k\rho \exp(-\delta^2);$$

and the latent heat is given by

$$\lambda = BT\{k'^2 \log(k\rho/k'\rho') + 1 - \rho'/\rho\},$$

from which we get approximately

$$T^{k'^2} \log(k\rho/k'\rho') = \text{const.}$$

On the assumption that $k' = k$, the data for both benzol and water give $k^2 = \frac{5}{3}$, which may possibly have a general significance. This theory with the former assumption respecting viscosity gives the still greater value $R'/R \doteq 10$ in the case of benzol. Finally, the equation

$$2K/(\rho + \rho') \doteq BT\lambda^2 \log(\rho/\rho')$$

gives K=15,800 and 13,400 atmos for Hg at 100° and 350°, K=12,000 and 1,900 atmos for water and benzol at 0°.

The last paper takes into account the influence of the collisions that occur in the layer that separates liquid from vapour, and also of the continuous variation in position of this layer itself in consequence of the collisions. The former modifies the equation $\rho'/\rho = \exp.(-\gamma^2)$ found in the first paper of the series into $(s-b)/(s'-b) = \exp.(-\gamma^2)$, where s denotes specific volume and $\frac{1}{4}b$ the actual volume of the molecules in unit mass; the latter supplies a correction of the expression of the latent heat which is not, however, verified by calculations from the results of Young's experiments. R. E. B.

1043. *Corrected Value of Rowland's Measurement of the Mechanical Equivalent.* **W. S. Day.** (Phys. Rev. 6. pp. 193–222, 1898.)—The author has compared three of Rowland's thermometers directly with three Tonnelot thermometers which had been completely studied at the Bureau International (two of which were broken in crossing the Atlantic). The Tonnelot thermometers were used exactly according to the directions given by Guillaume, in a specially constructed water-bath, which is described in detail. The Rowland thermometers could not conveniently be used vertically, as Rowland himself used them, but their pressure-coefficients were determined, and correction made for the difference

of position. The treatment of them with regard to zero-point was the same as Rowland adopted. The thermometers, when corrected to the absolute scale according to Rowland's tables, showed differences from the Paris hydrogen-scale amounting to $0^\circ{\cdot}032$ as a maximum. Rowland's values for the equivalent are recalculated accordingly, and the results given for each degree from 6° to 36°. The following is an abstract :—

Temp.		J.
6°	......	4·203
10	......	4·196
15	......	4·188
20	......	4·181
25	......	4·176
30	......	4·174
35	......	4·175

The minimum occurs at $31^\circ{\cdot}5$. $J = 4{\cdot}2 \times 10^4$ at $7^\circ{\cdot}5$.

The temperature-coefficient agrees well with Griffiths' values from 15° to 25°. The absolute values are less than Griffiths' by $\frac{1}{300}$ and less than Schuster's by $\frac{1}{400}$; the discrepancy is almost certainly not due to thermometric difficulties.

An abstract of the work occurs in the Phil. Mag. August 1897, but it contains an error. R. A. L.

1044. *Mechanical Equivalent of Heat.* **J. B. Baille** and **C. Féry.** (Comptes Rendus, 126. pp. 1494–1496, 1898.)—A copper cylinder is placed in a rotating magnetic field, produced by surrounding the cylinder coaxially with a ring to which, in a suitable manner, a two-phase current is supplied. The cylinder tends to rotate, but is prevented, the couple being measured by a balance. The frequency of the current is known, and the work spent on the copper can therefore be readily calculated. The rise in temperature of the cylinder is measured by a thermometer placed in a cavity, cooling corrections being applied. The values of the mechanical equivalent obtained vary from 422 to 426. The work is to be repeated with improved apparatus. A. Gs.

1045. *Numerical Evaluation of the Absolute Scale of Temperature.* **R. A. Lehfeldt.** (Phil. Mag. 45. pp. 363–379, 1898.)—Determinations of absolute temperature depend mainly on the measurement of the pressure-coefficient of a gas (hydrogen or air) and of the cooling-effect on outflow through a porous plug. Chappuis, at the Bureau International, has considerably advanced our knowledge of the former quantity; but the latter has, with one small exception, not been studied since the experiments of Joule and Thomson in the middle of the century. The experimental data are tabulated

and discussed, and a theory developed, leading to the equation

$$\log(1+100/T_0)=\frac{1}{1-K_p\epsilon/v}\log(1+100\beta),$$

where T_0 = absolute temperature of the freezing-point;
K_P = specific heat at constant pressure;
ϵ = cooling of the gas on expansion, per atmo.;
v = specific volume;
β = pressure-coefficient.

The values of T_0 derived from hydrogen, air, and nitrogen lie between 272°·8 and 273°·3; that for carbon dioxide is less reliable. The true value is probably very close to 273°·0.

When T_0 is found the absolute temperature T can be compared with the temperature t on the constant-volume scale for each gas by means of the equation

$$\log(T/T_0)=\frac{1}{1-K_p\epsilon/v}\log\frac{t+1/\beta}{1/\beta}.$$

A table is given for each gas, and the differences between each pair of gases compared with the difference found experimentally at the Bureau International. It is concluded that the normal (hydrogen) scale only differs from the absolute scale by less than a hundredth of a degree between 0° and 100°; but that it is not yet possible to reduce temperatures to the absolute scale with as high a degree of accuracy as it is possible to record them on the mercury-thermometer and reduce to the normal scale. And that to attain that result, and to settle the value of T_0 to 0°·05, it is necessary—

(*a*) To measure the coefficient of pressure for air, in the same manner as has been done for hydrogen, nitrogen, and carbon dioxide by Chappuis, and to extend the experiments on all four gases to initial pressures lower than one metre of mercury—say for 25, 50, and 75 cm.

(*b*) To redetermine the change of temperature on free expansion for *pure* hydrogen, nitrogen, and carbon dioxide over as wide a temperature as possible, paying particular attention to the question whether the cooling-effect is strictly proportional to the change of pressure, and its variation with the temperature: the experiments on hydrogen being the most important. AUTHOR.

ELECTRICITY.

1046. *Discharging Electricity by Ultra-Violet Light.* **J. Zeleny.** (Phil. Mag. 45. pp. 272–273, 1898.)—Air passed over a negatively charged body subjected to ultra-violet light will negatively charge glass wool through which it is passed, and will pass through chargeless; just as when Röntgen rays are used glass wool will discharge the gas (J. J. Thomson and E. Rutherford, Phil. Mag. Nov. 1896, p. 393); but with Röntgen rays the positive charge carried to the glass wool is less than the negative charge carried when light is used. A. D.

1047. *Stratification in Geissler Tubes.* **H. V. Gill.** (Amer. Journ. Sci. 5. pp. 399–417, 1898.)—The hypothesis is here put forward that the stratification of the electric discharge in Geissler tubes is due to gas-waves somewhat analogous to those which produce the dust figures in a Kundt's tube. This theory is supported by dust figures obtained by electric discharges at various pressures of gas. E. H. B.

1048. *Positive Influx towards the Kathode.* **P. Villard.** (Comptes Rendus, 126. pp. 1339–1341, 1898.)—The kathode radiation is fed by a supply of positively charged matter coming from the various parts of the vacuum-tube. The greater part of this current arrives in the central region of the kathode, owing to the repulsion of the walls. Hence the existence of a central kathode beam. The positive influx is visible near the kathode, towards which it converges. It is deflected by an electric field. The stopping of the positive influx at the kathode leads to the evolution of heat. When the kathode is perforated, a portion of the positive particles traverses the perforations, and we have Goldstein's canal-rays. E. E. F.

1049. *Magnetic and Electrostatic Deflection of Kathode Rays.* **W. Kaufmann.** (Annal. Phys. Chem. 65. 2. pp. 431–439, 1898.)—The magnetic deflection of kathode rays is inversely proportional to the square root of the difference of potential between anode and kathode. If V_0 is this difference, and J the intensity of the magnetising current, then the deflection is

$$y_0 = c\,J/\sqrt{V_0},$$

provided it is small, and the potential is that of the anode, except in close proximity to the kathode, as is usually the case in ordinary tubes. But if a different potential obtains along any distance along the direction of propagation, and is superimposed upon a magnetic field there, the deflection is

$$y_0 = CJ/\sqrt{V'},$$

where V′ is the difference of potential between the length considered

and the kathode, and C is a constant as before. The difference of potential between the anode and kathode therefore no longer influences the deflection. The above are results derived from the emission theory, and from the assumption that ϵ/m is constant. By allowing kathode rays to traverse a nearly closed space containing an electrostatic and a magnetic field, the author verifies the above formula, within the error caused by the dispersion of the magnetic lines of force. He makes out the ratio ϵ/m to be $1{\cdot}86 \times 10^7$ C.G.S. units per gramme. E. E. F.

1050. *Refractive Index of Glass for Electric Waves.* **J. C. Bose.** (Roy. Soc. Proc. 42. pp. 293–300, 1898.)—The author uses waves of a frequency of the order 10^{10}, and describes four methods of determination which, with their results, are as follows:—

(1) Total internal reflection from a single semi-cylinder, $\mu = 2{\cdot}08$
(2) „ „ two semi-cylinders, $\mu = 2{\cdot}04$
(3) Refraction from glass into air, $\mu = 2{\cdot}04$
(4) „ air into glass, $\mu = 2{\cdot}03$

The value of the optical index of the glass determined by the total-reflection method was found to be $\mu_D = 1{\cdot}53$. E. H. B.

1051. *Total Reflection of Electric Radiation.* **J. C. Bose.** (Roy. Soc. Proc. 62. pp. 300–310, 1898.)—A right-angled prism of glass receives electric radiation normally on one face so as to give total internal reflection from the hypothenuse face. A second prism like the first is then placed so that the hypothenuse-faces of the two prisms are parallel, an air-space intervening between them. Then, as the thickness of this air-space is diminished a critical value is found below which total internal reflection no longer obtains. This minimum thickness for total reflection varies with the angle of incidence and wave-length of the radiation, and in the cases given ranged between 13 and 5 mm. E. H. B.

1052. *Rotatory Polarisation of Electric Waves.* **J. C. Bose.** (Roy. Soc. Proc. 63. pp. 146–152, 1898.)—The author passes electric radiation through a polariser and an analyser, each of book-form as previously described by him (Roy. Soc. Proc. vol. 60). When polariser and analyser are crossed, the field is completely extinguished. On the interposition of a bundle of parallel jute-fibres 10 cm. long and 4·5 cm. diam., with the axis of the bundle parallel to the direction of the radiation, no effect is produced. When, however, the bundle is twisted and again interposed, the field is restored. It appeared, therefore, that a rotation of the plane of polarisation had occurred. To imitate the rotation produced by sugar solutions a number of small bundles of twisted jute-fibres were prepared, the twist of some being right-handed

and of others left-handed. The interposition of a number of either variety alone in the extinguished field restored the passage of radiation through the crossed polariser and analyser. But a number of the right-handed variety interposed together with an equal number of precisely similar left-handed bundles produced no effect on the field. E. H. B.

1053. *Electric Waves.* **C. Gutton.** (Comptes Rendus, 126. pp. 1092–1095, 1898.)—This note describes a case in which an electric wave proceeding along a wire may pass without change of phase to a second wire not in contact with the first. The two wires are in the same straight line, and the end of one is provided with a tube which encircles, without touching, the end of the other. E. H. B.

1054. *Universal Shunt.* **J. Rymer-Jones.** (Elect. Rev. 42. pp. 717–718, 1898.)—The author, in view of the incorrect opinion that Kelvin-Varley slides are not applicable as a universal shunt, gives calculations showing that the scale-reading is proportional to the multiplying power of the shunt. He then describes a simplified form of Kelvin-Varley slides, in which the 100-vernier coils are fixed to a movable ebonite disc, to which also are fixed the springs making contact with the main resistances. For the rough adjustment the whole disc is moved round, and the same handle serves, on loosening a detent, for the fine adjustment with the vernier coils. G. H. BA.

1055. *Diffusion and Conductivity of Gases.* **J. S. Townsend.** (Phil. Mag. 45. pp. 469–480, 1898.)—In this paper it is shown that some well-known phenomena connected with conducting gases may be explained by diffusion. The paper is divided into two sections, the first of which contains the solutions of some problems which apply not only to conducting gases, but also to gases in general. The question which is dealt with may be stated thus:—If there are two gases A and B contained inside a vessel the walls of which absorb A, what quality of A will remain unabsorbed and be left distributed throughout B after a given time has elapsed?

The following are the solutions of this problem for three particular forms of boundary: q_0 being the quantity of A in the vessel initially, the distribution of which is supposed to be uniform; q_t the quantity of A unabsorbed after a time t; κ the coefficient of diffusion of A into B.

1. When the boundary is a pair of parallel planes at a distance a apart,

$$q = q_0 \frac{8}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\epsilon^{\frac{-(2n-1)^2\pi^2\kappa t}{a^2}}}{(2n-1)^2}.$$

2. When the boundary is a cylinder of radius a,

$$q_t = q_0 \, 4 \left[\frac{\epsilon^{-\alpha_1^2 \kappa t}}{a^2 \alpha_2^2} + \frac{\epsilon^{-\alpha_2^2 \kappa t}}{a^2 \alpha_2^2} + \&c. \right],$$

where $a\alpha_1$, $a\alpha_2$, etc. are the roots of Bessel's function $J_0(x)$.

3. When the boundary is a sphere of radius a,

$$q_t = q_0 \frac{6}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\epsilon^{-\frac{\pi^2 n^2}{a^2} \kappa t}}{x^2}.$$

By means of the last equation a rough estimate could be made of the amount of impurity A that would be removed from a gas B by bubbling through a liquid which absorbed A. The solution shows that this amount depends on the rate of diffusion of A through B, and that in order to reduce the quantity of A to a given fraction the time the bubble takes to rise in the liquid must be proportional to the square of its radius.

The second section deals with the applications of these results to conducting gases. When the ion, or carrier of the electric charge, comes into contact with a conductor, it either gives up its charge, or remains in contact with the conductor held attracted to the surface by the electric force arising from its image. The surface of a conductor, therefore, acts like a perfect absorber of the charges on the carriers, so that a gas loses its conductivity owing to the ions coming into contact with the sides of the vessel which contains it.

If the charged carriers be considered as constituting the gas A and the rest of the molecules as the gas B, the solutions of the problems in Section I. can be applied to conducting gases if we give to q_0, q_t, κ the following definitions :—

q_0 the conductivity [or number of charged carriers in B] initially ;
q_t the conductivity at the time t;
κ the coefficient of diffusion of the carriers into the gas B.

The loss of conductivity of the gas due to the encounters between positive and negative carriers being neglected.

A simple consideration of the equations of motion of the gas gives a method of finding κ.

Let e denote the charge on the carrier ; u, v, w, the velocities of A parallel to the axes ; p the pressure of A ; n the number of carriers per c.c. ; x y z the electric forces at any point.

The equations of motion of A are of the form

$$Xe = \frac{1}{n}\frac{dp}{dx} + \alpha u.$$

If X is large, so that $\frac{1}{n}\frac{dp}{dx}$ may be neglected in comparison with Xe, then $\alpha u = Xe$. Let V be the velocity of the carrier when

acted on by a force of 1 volt per centimetre, which is $\frac{1}{300}$ in electrostatic units, and we obtain $a=\frac{e}{200V}$, so that when there are no electric forces acting on the gas the motion is given by three equations of the form:

$$\frac{1}{n}\frac{dp}{dx}+\frac{eu}{300V}=0,$$

or

$$-pu=\frac{300PV}{Ne}\frac{dp}{dx},$$

where N is the number of molecules in a gas at the temperature (about 15° Centigrade) at which the diffusion takes place, and at a pressure P, 760 mm.

This last form of the equation of motion shows that κ is $\frac{300PV}{Ne}$. If the charge e be taken as the same as the charge on an atom of oxygen in electrolysis, we have $1\cdot2Ne=\frac{3}{2}10^{10}$, since one electromagnetic unit of electricity, or 3.10^{10} electrostatic units, gives off from an electrolyte ·6 c.c. of oxgen. When dealing with air which has been made a conductor by Röntgen rays, $V=1\cdot6$ centimetres per second, so that $K=\cdot038$.

Using this value of κ in the formulæ given in Section I., the loss of conductivity of Röntgenized air due to bubbling through liquids or passing through tubes will be found. For example air, passing along tubing 10 centimetres long and 1 millimetre radius at the rate of 100 centimetres a second, would have its conductivity reduced to $\frac{1}{13}$th of its original value. This fraction can only be taken as roughly approximate, as the motion of a gas along a tube is not uniform across the section; the velocity being greater at the centre than at the sides, would have the effect of diminishing the number of carriers that would come into contact with the surface of the tube.

It will be observed that this theory shows that the loss of conductivity will be increased by reducing the size of the carrier, since the coefficient of diffusion κ would then be increased. This result agrees with the result of experiment, as there are several examples of conducting gases which can be passed through fine tubing, or a plug of glass wool, without losing much of the charge; and it has been found that, when acted upon by an electromotive force, the carriers move much slower than the carriers in a gas made a conductor by Röntgen rays.

It can therefore be concluded that when a gas retains its conductivity after passing through wool or bubbling through liquids, that the carriers are too large to diffuse rapidly, and are small compared with the apertures through which the gas passes.

AUTHOR.

1056. *Conductivity of Gases.* **R. W. Wood.** (Phys. Rev. 6. pp. 165–166, 1898.)—A compact apparatus of the kind devised by Kuntz is described, for showing the conductivity of gases. A larger bulb containing the gas to be tested (or a vacuum) surrounds a smaller bulb containing ether and communicating with a nozzle. On immersion in boiling water the ether is more or less rapidly evaporated according to the conductivity of the intervening gas, and the vapour will burn at the nozzle in a jet of corresponding height. The bad conductivity of a vacuum is well shown. Glass-working directions are given. A. D.

1057. *Determination of Thermal and Electric Conductivities.* **P. Straneo.** (Roma, R. Accad. Lincei, Atti, 7. pp. 197–202, 1898.)—A mathematical paper showing how it is possible, by simultaneous observations, to ascertain both the thermic and the electric conductivities of a wire at high temperatures. The errors due to slight mismeasurements of the points at which certain stationary temperatures are observed is very small. A. D.

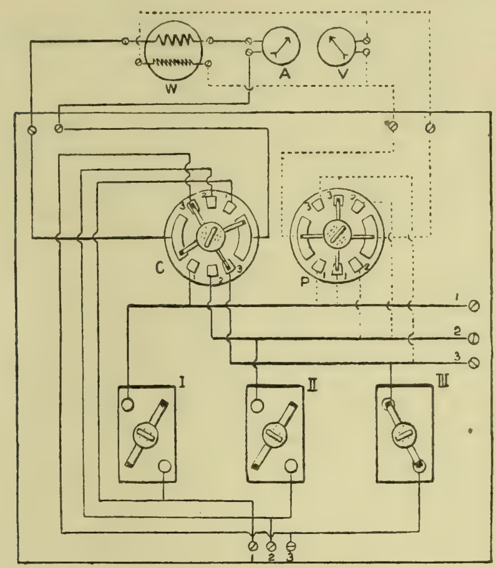
1058. *Dielectric Constant of Ice.* **R. Abegg.** (Annal. Phys. Chem. 65. 1. pp. 229–236, 1898.)—The author attributes the varying values of the dielectric constant of ice obtained by Dewar and Fleming, not to electric dispersion, nor, as he previously suggested, to electrolytic polarisation, but to residual conducting-canals within the substance of the ice, either unfrozen or formed by chains of conducting electrolytes remaining after purification. E. E. F.

1059. *Cadmium Standard Cell.* **P. Kohnstamm** and **E. Cohen.** (Annal. Phys. Chem. 65. 2. pp. 344–357, 1898.)—The Weston cadmium cell shows an irregularity in the temperature coefficient below 5° which renders its use in the cold less satisfactory. The authors investigate the cause of the irregularity and discover it in the fact that the curve of solubility of the cadmium sulphate undergoes a sudden change at 15°, remaining stationary between that temperature and 20°. This is no doubt due to some change in the constitution of the salt, which under ordinary circumstances corresponds to the formula $CdSO_4 \cdot \frac{8}{3}H_2O$. This change is analogous to the change of crystalline form undergone by sulphur at 95°. The Weston cell should only be used at temperatures above 15°. It then is much more stable than the Clark cell. E. E. F.

1060. *Tri-phase Power Measurements.* **M. Aliamet.** (Électricien, 15. pp. 243–246, 1898.)—The author shows that the power given to a tri-phase circuit can be measured by two wattmeter readings, viz.: it is given by

$$P = p_{13}c_3 + p_{12}c_2,$$

where c_2, c_3 are respectively the currents in the second and third wires, and p_{13}, p_{12} the differences of potential between the first and third, and the first and second wires respectively. He then goes on to describe a single wattmeter by which both these readings may be taken in quick succession. It is shown diagrammatically in the accompanying figure. C and P are commutators, by means



of which the thick and thin coils are placed first in one circuit and then in the other. The line-wires are brought to terminals 1, 2, and 3. The switches I, II, III serve to short-circuit the instrument. To take readings the switches II and III are closed, and the commutator C is so placed that the thick wire of the wattmeter is inserted in the line-wire c_3, while the commutator P is arranged so as to connect the thin wire across the terminals 1 and 3. Opening switch III and closing I and II the first reading is taken. Similarly, by closing switches I and III, opening II, and changing the commutators C and P, the second reading is taken. W. G. R.

1061. *Magnet Poles.* **G. Schürr.** (Journ. de Physique, 7. pp. 282–285, 1898.)—When a current acts on a magnet, the points of application of the resultant of the action due to each element must not be confounded with the magnetic poles. The author puts an infinite horizontal current in the magnetic meridian at a distance b from a magnet movable round a vertical axis, as in Oersted's experiment, and arrives at the following conclusions:—Let 2 L represent the actual length of the magnet, 2 X the dis-

tance between the poles due to the current, $2l$ between the poles due to the earth's magnetism, whose horizontal component is H. A cylindrical needle of 110 mm. length and 2 mm. diameter of tempered steel magnetised to saturation, the current has a value 0·43 amperes, and b is varied from 16·2 cms. to 25·5 cms.

$$2X/2l \text{ varies from } 0{\cdot}6 \text{ to } 0{\cdot}7.$$

Thus in the case where $2l = 80$ mm., $2X$ varies from 48 mm. to 56 mm. as the current approaches from 25·5 cms. to 16·2 cms.
E. C. R.

1062. *Magnetic Intensity Variometer.* **A. Heydweiller.** (Annal. Phys. Chem. 64. 4. pp. 735–741, 1898.)—Two equal declination needles are mounted on a common axis, one above the other, so that each makes an angle of 45 deg. with the magnetic meridian. Thus each of the four poles moves in a nearly uniform magnetic field, and any variation of the earth's horizontal force is indicated by a proportional rotation of the needles. On this principle the author constructs a magnetic variometer. Two rhombic needles vibrate over copper plates in a cylindrical case. Their distance apart is about 6 cm., and can be adjusted at will. The lower needle carries two aluminium pointers, which travel over a divided scale attached to the upper one, and indicate the relative rotation of the two needles. E. E. F.

1063. *Magnetic Torsion of Iron and Steel.* **G. Moreau.** (Journ. de Physique, 7. pp. 125–131, 1898.)—An iron wire is surrounded for part of its length by a bobbin. As discovered by Wiedemann, if the wire be twisted and then an electric current be sent through the bobbin, producing a magnetic field, the angle of twist is increased. By imagining the wire composed of an infinitude of elementary magnets, and finding an expression for the couples acting on them, the author deduces a theory, which, for fields and twists which are not too great, agrees with his experiments. Amongst other things he proves that the magnetic torsion is proportional to the torsion at the point considered, to the square of the intensity of the field (if it is weak), and that it is independent of the diameter of the wire. A. Gs.

1064. *Magnetisation of Solid and Hollow Rings.* **F. Kirstädter.** (Annal. Phys. Chem. 65. 1. pp. 72–85, 1898.)—A ring, about 17·3 cm. external and 11·3 internal diameter (*i.e.* width of section about 3 cm.) is turned from an iron plate, and cut equatorially; each half is provided with a groove which is subsequently widened, and finally a solid ring is fitted into the hollow. Thus were obtained a solid ring, two half rings, three hollow rings of different thickness, and an inner solid ring, which were tested

singly; the smallest and the inner ring were also combined. The rings were annealed for 24 hours in a charcoal fire and further subjected, in each case, to about a hundred cycles of magnetisation, in order to arrive at a permanent magnetic state. One layer of primary wire was coiled all over the ring; the secondary winding over this layer covered about a third of the circumference. Determinations were made with the help of a Du Bois-Rubens ballistic galvanometer; the field varied between 0·02 and 68 c.g.s. units. The very regular curves do not demonstrate any magnetic screening in the sense of von Feilitzsch and Grotrian. The magnetisation curve of the solid ring lies below that of the solid half and hollow rings whose curves follow more closely to one another in the order of their decreasing thickness. The action of Foucault currents, which would affect measurements made with the solid ring more than those of the split rings and the hollow rings still less, would probably suffice to explain the observed differences. H. B.

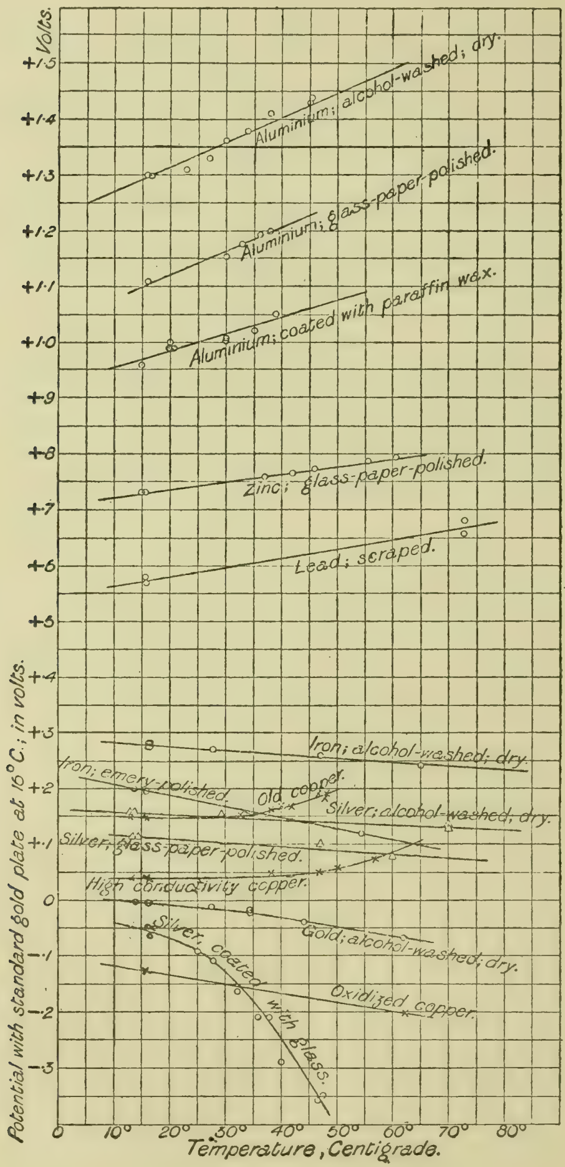
1065. *Contact Electricity of Metals.* **J. Erskine-Murray.** (Roy. Soc. Proc. 63. pp. 113–146, 1898.)—This experimental investigation had as its primary object the elucidation and measurement of the variation of Volta contact electricity of a pair of conductors, due to changes in the state of *that portion of the surface of each conductor which was separated from the other conductor by an insulating medium.*

The Volta-potential difference between two metals was measured, usually in air, by the null method described by Lord Kelvin in the B. A. Report for 1880, p. 494. The metals were in the form of circular discs, about 9 cm. diam. and ·2 cm. thick. Precautions were taken in order to determine as exactly as possible the actual condition of the surfaces in every experiment. On account of the large variety of experiments described, it has been found difficult to make a satisfactory abstract; what, appear, however, to be the most important results are given below.

(*a*) Metals covered with non-conducting solid films of wax or glass, except at their point of contact, give nearly the same potential as the bare metals in air. The substitute of wax for air next the metal only causes a small change which may be in the same direction and of approximately equal amounts for metals whose potentials in air are very different; *e.g.*, the Volta-potential difference between zinc and copper when both are coated with solid paraffin wax is very nearly the same as that between bare zinc and copper, and is also nearly the same as that of bare copper and waxed zinc, or *v. v.*, in air. The potential of sodium, coated with wax and glass, was found to be about 3·56 volts positive to a standard gold plate of electrolytically deposited gold, which had been washed with alcohol some hours previously.

(*b*) A metal cleaned by careful polishing or scratching with emery-cloth or glass-paper is less positive when its surface is in a sharply scratched condition than when smooth or burnished, the

difference frequently amounting to 0·2 or 0·3 of a volt. The change being probably caused by a hardening of the surface-layers. The author points out that this result is not in opposition to



Pellat's*, for the conditions were different, as Pellat's plates were washed with alcohol after polishing.

(*c*) The temperature variations, between 15° C. and 60° C., of the Volta-potential of many metals have been determined, both for clean dry metals in air and for metals coated with liquid or non-conducting solid films; and it has been found that they are of considerable magnitude in both cases. The curves representing the variation of potential with temperature appear as if they should meet at a point below −200° C., at a potential about 0·4 volt positive to a standard gold plate at 16° C.; this suggests that Volta-potential differences may possibly vanish at a very low temperature.

(*d*) A liquid film, even if of extreme thinness, may cause a considerable change in the potential of a dry polished plate, which continues permanent for many hours and even days after the disappearance of the film. The results of many experiments made with alcohol and other liquids on gold, silver, zinc, copper, iron, tin, lead, and aluminium are given. It is noted that in almost every case the contact-potential of a metal which has been polished on a hardly dry material rises at least 0·15 volt in consequence of alcohol washing, and that this change is nearly permanent for many hours after the plate appears to be quite dry.

Two films of the same liquid opposed to one another on the surfaces of two plates of different metals do not usually give zero potential-difference, as solid conducting films of one material would do, but give nearly the same potential-difference as the dry metals on which they lie.

(*e*) A very thin film of oxide on a metal produces only a very small change in the potential, and every increase in thickness of the film is attended by a further change in potential until a limiting value is reached, which is that of a mass of the oxide.

(*f*) Exposure to the atmosphere at ordinary temperatures does not, as a rule, produce any rapid change in Volta-potential, especially if the air be comparatively dry and free from dust. The ultimate change is usually in the negative direction.

(*g*) Experiments were made to find the result of immersing a metal in a gas other than air, as in Lord Kelvin's experiments (Nature, 1881). One plate only was immersed in the gas for a short period, in some cases of only a few minutes, in others as long as 45 minutes, its potential with a standard plate being measured, in air, before and after immersion in the gas. This method gives the variation of potential, relative to the fixed standard, due to temporary alteration of the surface-film on the plate. Immersion in oxygen caused copper, zinc, and silver to become temporarily positive, while tin and platinum became negative. The potentials returned to very nearly their original values a few hours after the plates were taken out of the oxygen bath.

AUTHOR.

* Ann. de Phys. et de Chimie, 1881.

1066. *On the Theory of Magneto-Optic Phenomena.* **C. H. Wind.** (Phys. Rev. 6. pp. 98–113, 1898.)—Having previously obtained various equations (see Abstract No. 504), the author proceeds to consider the case of light incident on an interface of two media, one of which is conducting, in a field of given external magnetic force. The incident ray being plane-polarised, he assumes that the refracted light in the conducting medium will consist of two rays circularly polarised in opposite directions, and the problem is considered what must be the constitution of the incident light in order that the refracted ray may be polarised in a given manner. In order to solve this, he deals first with the reflected ray, and finds that as a consequence of the magnetic force, there will be, in addition to the ordinary reflected ray, which is polarised in the same plane as the incident light, another component polarised in a plane at right angles to this last. This he calls the magneto-optic component. It constitutes the phenomenon known as the Kerr effect. It can be derived from equation C of the former abstract, p being a complex constant. In this relation he compares his results with those of Van Loghem, Sissingh, and Zeeman.

It has been asserted by some writers that if the magnetic force be perpendicular to the plane of incidence, no magneto-optic effect is to be expected. But the theory indicates that an optical effect of another kind will be produced, namely, a change in the quantities known as the "phase difference ϕ, and the re-established azimuth h." And he refers to Zeeman as having observed this effect.

Drude's theory is then discussed. It differs from that of Wind only in using a real instead of a complex quantity for the magneto-optic constant. Drude's theory, and also Goldhammer's, are based on Maxwell's division of the electric current into a conduction and a displacement current, a hypothesis which is not introduced by Wind.

Then is enunciated as axiomatic the following "principle of symmetry":—*If any system can be considered as its own reflected image, not only as regards the position of the material points of the system, but also as regards the laws of their mutual action, then corresponding to every possible state of motion of the system, there is another state which behaves towards the first as its reflected image.* From this assumed principle he deduces the effect of magnetisation on the reflected light.

Then is proposed an explanation of the complex nature of the Hall constant (equation C). Drude's theory, in which the Hall constant is real, corresponds to the assumption that no Hall effect is to be attributed to the conduction-current.

It is shown that all the author's equations A, B, and I. . . VI. are deducible from Lorenz' theory of the motion of electricity by ions. The remaining equation C of the author's theory is to be obtained by assuming that the velocity of the cations is not precisely the same as that of the anions, as has been suggested before.

S. H. B.

1067. *Apparent Electrification in an Electric Field at the Bounding Surface of two Dielectrics.* **A. Anderson.** (Cambridge Phil. Soc. Proceedings, 9. 6. pp. 292–294, 1897.)—The two dielectrics, having inductive capacities K_1, K_2, are separated by a surface S. If there be no real surface distribution on S, there is discontinuity of the normal electric forces owing to the variation of K; and σ' is the density of that distribution on S, which in a hypothetical case where K_1 and K_2 are both unity, *cæteris paribus*, would produce the given discontinuity of force. Maxwell calls σ' the apparent electrification. Now Maxwell says that if the apparent electrification be discharged "by passing a flame over" S, then when the inducing force is taken away there remains on S a true distribution of opposite sign to σ'. And this is described in an appendix to Maxwell's chapter as the result of the conducting flame being connected with the earth. According to Gray ('Absolute Measurements in Electricity and Magnetism') the action of the flame reduces S to *zero potential*. According to Mascart and Joubert it reduces S to *the neutral state*, and when the sources of induction are removed, there remains on S a real layer of density the same as the fictive layer, or apparent electrification.

According to Wiedemann (Die Lehre von Electricität, Band II.) the flame removes the apparent electrification, and produces a real electrification of opposite sign, *depending on the action of the apparent electrification in the interior of the body.*

Professor Anderson shows by an example that even if the flame reduces S to zero potential, the real distribution so produced is not necessarily of the opposite sign to σ'. His view is as follows: Let σ_1 be that distribution on S which in the actual case (K varying) would make the normal force continuous. Then the effect of discharging the apparent electrification is to produce on S the distribution σ_1. Now zero in the actual case corresponds to σ' in the hypothetical case, and σ_1 in the actual case corresponds to zero or $\sigma' - \sigma'$ in the hypothetical case, so that the action of the flame produces on S_1, not $-\sigma'$, but a distribution σ_1, which is equivalent to the apparent electrification $-\sigma'$. S. H. B.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

1068. *Fifth Annual Report of the Committee on Atomic Weights.* **F. W. Clarke.** (Chem. News, 77. pp. 239–242, 1898.)—Papers published during 1897 which bear on atomic weights are critically reviewed. The papers considered refer to the atomic weights of carbon, nitrogen, chlorine, silver, aluminium, nickel, cobalt, tungsten, and cerium. A complete list of atomic weights is given which differs from that published in 1896 in the following instances:—carbon = 12·00, cerium = 139·35, cobalt = 58·99, when O = 16. Rummel (Proc. Roy. Soc. of Victoria (Australia) x. pt. 1, p. 75) has worked out relationships between the spectra of the alkali metals and their atomic weights, from which the latter may be calculated with fair accuracy. T. E.

1069. *Liquefaction of Hydrogen and Helium.* **J. Dewar.** (Comptes Rendus, 126. pp. 1408–1412, 1898.)—Hydrogen cooled to $-205°$ and under a pressure of 180 atmospheres is allowed to escape rapidly through a coil of tube into a vacuum vessel, doubly silvered and surrounded by a vacuous space maintained below $-200°$ C. About 1 % of the gas is obtained in the form of a clear colourless liquid showing no absorption spectrum, and with a well-defined meniscus and apparently high refraction and dispersion. A glass tube closed at one end plunged into it becomes filled with solid air. Helium is similarly condensed to a liquid. T. E.

1070. *Equilibrium in the Ternary System; Lead, Tin, Bismuth.* **G. Charpy.** (Comptes Rendus, 126. pp. 1569–1573, 1898.)—Lead, tin, and bismuth are miscible in all proportions, at suitable temperatures, and form neither compounds nor isomorphous mixtures with each other. In mixtures containing these metals one liquid phase and three solid phases (consisting of the three pure metals) are therefore alone possible. The author has determined the freezing-points and compositions of 56 alloys of the three metals, and represents the results by means of the usual equilateral triangular diagram. The ternary eutectic alloy contains about 32 per cent. of lead, 16 per cent. of tin, and 52 per cent. of bismuth, and melts at 96°. T. E.

1071. *Microstructure of Nickel and Iron Alloys.* **F. Osmond.** (Comptes Rendus, 126. pp. 1352–1354, 1898.)—Alloys containing up to 8 per cent. of nickel have a structure resembling that of

ordinary steel, the granulation being however somewhat finer. Alloys containing 12 to 25 per cent. of nickel show (on a polished and etched surface) fibrous rectilinear bundles, the orientation of which is parallel to three main directions. The characteristics of this group are, except in minor details, those of hardened steels. The non-magnetic alloys containing about 25 per cent. of nickel and those which contain 30 to 80 per cent. of nickel (and are magnetic owing to this excess of nickel) form a third group, having a purely crystalline structure. After etching, these alloys are seen to be full of small pin-holes. This classification is identical with that based on the mechanical properties of the alloys. T. E.

1072. *Electromotive Properties of Chromium.* **W. Hittorf.** (Annal. Phys. Chem. 65. 2. pp. 320–343, 1898.)—The position of chromium in the electromotive series depends upon its chemical state. Fresh fractures of the metal are in an active state, corresponding to the oxide CrO_3, and in that state the metal stands immediately above zinc, and precipitates other metals from their solutions. In the inactive state, corresponding to the oxide CrO, it is a noble metal, reduces no other metal from its salt solutions, and stands at the electro-negative end of the series next to platinum. Experiments with a large number of different electrodes and electrolytes show that chromium as an anode may, with the same electrolyte, assume each of its three grades, according to the solvent and the temperature. By modern processes the metal can be obtained in large quantities, completely fused and free from carbon. E. E. F.

1073. *Solid Solutions of Organic Compounds.* **G. Bruni.** (Roma, R. Accad. Lincei, Atti, 7. pp. 166–171, 1898.)—The author describes a series of experiments made in order to discover what similarity of constitution between two compounds determines the formation of a solid solution, and the consequent abnormal cryoscopic behaviour of the substances. The results hitherto obtained refer chiefly to closed chain compounds, and it has been found that solid solutions are produced from two compounds which differ in composition by two atoms of hydrogen, such as naphthalene and its dihydride. This rule, however, does not hold good for open-chain compounds, since solutions of oleic acid, stearic acid, and of butyric acid in crotonic acid, exhibit the normal cryoscopic depression. In explanation of these facts it is urged that the formation or disruption of a double bond must cause a much greater alteration in the molecular symmetry of an open chain than in that of a closed chain compound. Examples of the formation of solid solutions in the case of open-chain derivatives must, therefore, be sought among compounds of identical molecular configuration, such as carbon tetrachloride and tetrabromide, trichloracetamide and tribromacetamide, the behaviour of which has already been investi-

gated by other observers. The present paper gives the results of experiments made with solutions of chloroform and iodoform in bromoform, and of ethylene chloride and iodide in ethylene bromide. In each case the formation of a solid solution is indicated by cryoscopic determinations at various concentrations, and this is confirmed, in the case of iodoform dissolved in bromoform, by analyses of the separated crystalline mass and of the mother liquor. Theoretical considerations, based upon a comparison of the melting-points of the above-mentioned compounds, lead to the supposition that the abnormalities will be much more pronounced in the case of the iodine than in that of the chlorine derivatives. and this is in complete harmony with the facts observed. J. W.

1074. *Electrolytic Analysis.* **G. Arth.** (Écl. Électr. 14. pp. 106–109, 1898.)—The writer gives the methods of various authors for the separation of a number of metals. W. R. C.

1075. *Electro-deposition of Metals.* **J. C. Graham.** (Elect. Rev. 42. pp. 278–279, 319–320, 357–358, & 458–460, 1898.)—In this paper, which was communicated to the Royal Society, the author gives an account of experiments carried out chiefly with regard to the deposition of copper. Molecular motion does very little to compensate for the dilution caused by the deposition at the kathode, and therefore copper cannot be satisfactorily deposited if the current-density at the kathode much exceeds 300 amperes per square metre. But the current-density may reach ten times this value if the electrolyte is given a very rapid circulation, and the kathode also shielded about the edges to prevent the formation of trees. In the case of copper anodes the current-density is found to fall very rapidly from its initial value (when high), but this does not occur if lead is used as an anode. If there is a rapid circulation this drop does not take place. The pressure between the electrodes also varies abnormally unless the electrolyte is in circulation. The author concludes with examples of the deposition of copper from impure solutions. The colour of the deposit is brown if the solution includes much chloride. W. R. C.

1076. *Polarisation and Electrolysis.* **M. Del Proposto.** (Bull. Ass. Ing. El., Liège, 9. pp. 36–57, 1897.)—The author has investigated certain discrepancies which are found to occur between the observed electromotive force of polarisation and the value determined by Kelvin's law, for various solutions. He describes some experiments in which the terminal potential difference and the polarisation E.M.F. were measured for gradually-increasing currents, and obtained curves similar to curves of magnetisation, *i. e.*, two substantially straight lines connected by a curve. From this the author draws the following deductions, viz.:—Assuming that the two ions of the electrolytic molecule are charged with electricity of opposite sign so as to form a kind of

elementary electromagnet, then, under the action of the electric force, the small magnets will be turned with their similar poles to the same sides, and the electrolyte will form a kind of magnet which only presents free masses (? magnetism) at the surfaces in contact with the electrodes. The mean intensity of magnetisation, which corresponds to polarisation in condensers, will be equal to the mean density of electricity on the extreme faces of the electrolyte, and the intensity of the current corresponds to the intensity of the field in the phenomena of magnetisation.

The author also investigated the effect of introducing diaphragms of glass and metal into the liquid between the electrodes, the diaphragms extending to various depths in the liquid. He found that the increase of potential difference for a given current passing through the voltameter follows approximately the same law as the fall of pressure produced by throttling a water-conduit. The author also discusses the "secondary electrolysis" which is set up when the diaphragm is made of conducting material. C. K. F.

1077. *Secondary Electrolysis.* **E. Andréoli.** (Ind. Électrochim. 2. pp. 36–38, 1898; also Génie Civil, 9. t. 27, 29 June, 1895.)—If an electrolytic cell be divided into three compartments by means of porous partition-walls, and be filled with the same electrolyte, a current passed through it by means of electrodes in the two outer compartments does not produce any change in the central compartment of the cell. If, however, one or more insulated metal plates be immersed in the liquid in the latter, electrolytic decomposition occurs, and to this the author gives the name of "secondary electrolysis," and states that he is the discoverer of this phenomenon.

As examples of secondary electrolysis he gives the following:—

1. Deposition of gold from a gold-cyanide solution placed in the central compartment, lead plates being used to receive it. In the outer compartments solutions of sodium chloride are used with a gas-carbon anode, and an iron kathode.

2. Deposition of gold from gold-cyanide solution in central compartment.—The outer compartments were filled with the same solution of gold cyanide, but after many days no change could be detected in the gold contents of the liquid in these compartments.

3. Conversion of sodium bisulphite into hydrosulphite.—The side compartments in this case may contain any electrolyte; the central compartment is fed with a solution of the bisulphite, and only two metal plates are immersed in it. Bleaching operations can be effected by means of the liberated hydrosulphite.

The author considers that these observations and facts are in conflict with the modern theory of ionic transportation, and he closes his article with a request to electrochemists for criticisms and suggestions upon the subject. J. B. C. K.

1078. *Electrodes for Electrolysis of Alkali Metal Chlorides.* **H. Becker.** (Ind. Électrochim. 2. pp. 25–26, 1898.)—The materials

generally used for electrodes to be employed in salt solutions containing chlorine are gas-carbon, or graphite with which ordinary coke is sometimes mixed to form a moulding compound. High density is one of the chief characteristics required of the product. Girard and Street and Castner convert ordinary carbon into graphite by heating it in closed boxes to the temperature of the electric arc. Other inventors have described electrodes of high resistance towards chlorine, made by moulding mixtures of powdered carbon and tar under pressure, and heating to 1000° C. The use of rough blocks of gas-carbon, made into one conducting medium in various ways, has been patented by many inventors. Others have suggested the use of metallic oxides—as, for example, Gerald and Falconer, peroxide of lead, and Blackman, magnetite or ilmenite.

Electrodes formed of an alloy of platinum and iridium are in actual use in several works producing bleach and chlorates. Platinum alone is not found sufficiently resistant to the chlorine; while platinised electrodes are still less satisfactory. The forms of the platinum-iridium electrodes are very diverse. In the chlorate works they are generally made by stretching thin sheets of the alloy over a wire frame of the same. Kellner has patented a form in which short platinum wires are embedded in an ebonite plate. Hoepfner has patented the use of ferro-silicium; but this was previously described by Uelsmann. Parker and Robinson have suggested chromium phosphide. As materials for kathodes, gas-carbon, iron, and nickel are in actual use. Fluid kathodes have been patented by several inventors: Castner and Kellner have used mercury, while Vautin and Hulin have used molten lead. Finally, Richardson and Holland, and Franchot and Gibbs have patented the use of copper oxide. Short descriptions of many of the above Patents are given. J. B. C. K.

1079. *Diaphragms for the Electrolysis of the Alkali Metal Chlorides.* **H. Becker.** (Ind. Électrochim. 2. pp. 33–34, 1898.)—Many materials for diaphragms have been proposed, but only few have received experimental trial. Parchment-paper has been suggested by Le Sueur, Kiliani, Rathenau and Sutter; it is in actual use at Rumford Falls, U.S.A., and at Bitterfeld in Germany. At Leopoldschall parchment protected by a coating of calcium or magnesium oxychloride is used in the electrolytic cells.

Rieckmann describes diaphragms of albuminised paper, or of albumen alone; while Hoepfner has suggested the use of paper or cardboard coated with collodion. Diaphragms of unglazed porcelain or baked clay have been patented by many, and are in actual use in three works. Asbestos as a material for diaphragms has been patented by Roberts and McGraw, Hargreaves and Bird, Riquelle, Wiernick, Waite, Hempel, Richardson, and by Lucius and Bruning. Porous partition walls of Portland cement have been patented by Breuer, Hurter, and by Carmichael. Brief descriptions of all the Patents named above are given by the author.

J. B. C. K.

GENERAL ELECTRICAL ENGINEERING.

1080. *Storage-Batteries in America.* **J. Wetzler.** (Elect. Engin. N. Y. 25. pp. 443–460, 1898.)—This is an illustrated account of the works of the Electric Storage Battery Co. of Philadelphia and of the processes involved in the manufacture of their storage-cells. Particulars are also given of some large batteries installed in central stations, tramway stations and lighting plants, and of their application in telephone exchanges, and for telegraphic purposes. The positive plates, "Manchester" type, consist of a grid of antimonious lead with coils of corrugated lead tape forced into the apertures under hydraulic pressure. The tape is corrugated, cut into lengths, and coiled by an automatic machine which does the same work as 40 to 50 boys. The negative plates are constructed of pellets or pastilles of cast lead chloride—hence the name "Chloride Accumulator"—held together by a frame of antimonious lead cast round them. They are then placed between sheets of zinc in an electrolyte of zinc chloride, and the pastilles reduced to a highly crystalline form of porous lead. Finally, they are subjected to several washings and constituted kathodes in an electrolytic bath for some hours to ensure the entire elimination of chlorine from the pastilles. Both the positive and negative grids are cast under a pressure of 100 lbs. per sq. in. E. J. W.

1081. *Variation of Capacity of Accumulators with Discharge Rate.* **J. Reyval.** (Écl. Électr. 15. pp. 143–146, 1898.)—W. Peukert found that the current I and time of discharge t are related by the formula

$$I^n t = k,$$

in which n and k are constants for any particular type of cells. The author gives an account of the results obtained by F. Loppé in verifying this law. A set of curves is given showing the marked variation of capacity. W. R. C.

1082. *Lead-Zinc and Cadmium Accumulators.* (Écl. Électr. 15. pp. 242–244, 1898.)—The use of zinc instead of lead for the anodes of accumulators (*e. g.* that of Regnier) offers the advantages of an increased E.M.F., and also, owing to diminished weight, of an increased specific capacity. Unfortunately, the zinc dissolves when the circuit is open, a defect which is very imperfectly remedied by amalgamation, and hence Commelin and Finot use cadmium instead. In the Werner accumulator the electrolyte is a solution of the mixed sulphates of zinc, cadmium, and magnesium. In charging, a coherent deposit of zinc and cadmium is obtained, which is practically unattacked when the circuit is open, the magnesium playing a little-understood but most important part.

It is found that if a concentrated solution of zinc sulphate is used alone a good deposit of zinc is produced, but the peroxidation of the kathode is feeble; whilst if cadmium sulphate be employed a good deposit and satisfactory peroxidation are obtained, but the E.M.F. falls off rapidly during the discharge. On the other hand, with dilute solutions of either salt, peroxidation is well effected, but a poor deposit is obtained. The addition of magnesium sulphate allows of the production of all the necessary conditions by means of solutions of moderate strength; nevertheless it is better to use more dilute solutions for rapid than for slow discharges. Some minor improvements are also made in the construction of the positive plates, with the object of bringing the active material into closer contact with the conducting support. The accumulator has a capacity of 82 watt-hours per kilogram of plates, or 36 watt-hours per kilogram of total weight, the current being 12–15 amperes. The E.M.F. is 2·4 volts at the commencement, and 1·9 volt at the end of the discharge. J. W.

1083. *Electrical Press-room.* (West. Electn. 22. pp. 221–222, 1898.)—This is an account of the motor-driven presses of the 'Chicago Record' and 'Daily News.' Each press is driven by two motors, one for driving purposes and a smaller slow-speed motor to manipulate the press in "making ready." An important feature of this installation is Mr. Stone's electro-pneumatic system of motor-control. Compressed air is used to operate the contact-arms of the rheostats, and at a number of convenient points on each press air-valves and push-buttons are located. The handle of an air-cock controls, through the specially constructed rheostat, the slow speed-motor, which is used in "dressing the press" or in making ready to run off an edition. This valve is constructed with three inlets and an exhaust, and can be set—first, to run the press slowly; second, to stop the press; or, third, to cause the air to go through a by-pass in such a manner that the press cannot be started from any other point. W. G. R.

1084. *Reiter's Speed-Regulator for Turbines.* (Écl. Électr. 15. pp. 290–293, 1898.)—An illustrated description of **H. Reiter's** electric brake for use as a speed-regulator in the case of turbines working under a small or moderate head of water—in which case a difficulty has always been experienced in maintaining a sufficiently constant speed with large variations of load. The device consists of a small centrifugal governor which, by raising or lowering a mercury vessel, alters the amount of resistance included in the circuit of the brake-electromagnet. The brake itself consists of a fixed central electro-magnet with re-curved pole-pieces, and an outer ring of steel or iron, which is driven by the turbine, and which absorbs more or less power by the eddy-

currents induced in it, according to the degree of excitation of the magnet. The regulator is said to be much quicker in action than one in which a hydraulic brake is used. A. H.

1085. *Electric Governor for Marine Engine.* **E. Putato.** (Ecl. Électr. 15. pp. 293–294, 1898.)—Two mercury-vessels attached to a longitudinal wall of the ship communicate with each other by means of a connecting-pipe. As the ship pitches, causing the propeller to rise either partially or wholly out of the water, mercury flows from one of the vessels into the other, the effect being to gradually short-circuit a set of resistances connected to contact-pins, which pass into the space above the mercury contained in the vessel nearer the bow of the ship. As these resistances are cut out, the current through one of a pair of electromagnets controlling the main steam-valve increases, and the valve is gradually closed. When the bow of the ship rises, the resistances are gradually inserted, and before the last pin rises above the mercury, an auxiliary electromagnet closes the circuit of the second large electromagnet controlling the valve, which is thereby opened. In the normal position of the vessel, no current passes through either electromagnet. A. H.

1086. *Morrison's Apparatus for Power Conversion.* (West. Electn. 22. pp. 277–278, 1898.)—The apparatus constitutes a variable speed-gear designed primarily for horseless carriages; the one in question weighs about 200 lbs., and is of 4 H.P. A gas or oil-engine runs at a constant speed of 600 revs. per minute, and is regulated by a centrifugal governor. To the shaft is fixed a cylinder carrying field-magnets. Mounted upon the shaft, but free to revolve upon it, is a Gamme ring-armature with commutator. When the vehicle is at rest the armature is stationary, and in starting, after the electric circuit is closed, the greatest current is generated. As the speed of the armature increases the energy exerted diminishes and the speed of the carriage increases.
A. S.

1087. *Comparative Tests of Injectors.* **G. H. Trautmann.** (Mech. Eng. 1. p. 551, 1898.)—A digest of a series of tests of the performance of steam-injectors by nine different makers.
A. S.

1088. *Belt Driving.* **J. Tullis.** (Mech. Eng. 1. pp. 452–454, and pp. 487–490, 1898.)—The author discusses the manufacture and care of leather belts for main-driving. High-speed belts running over 4000 ft. per minute should be made of single, pliable, tough thin leather; by compounding such belts, they may be run

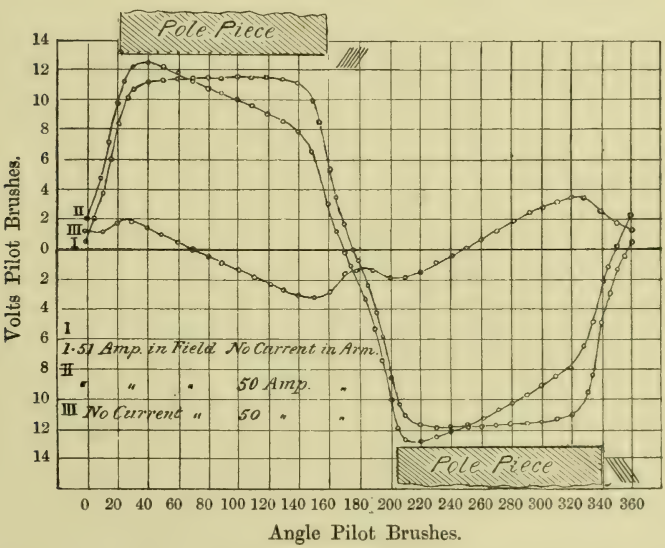
with advantage up to 9000 ft. per minute. Compound belt-driving is a simple and most trustworthy means of transmitting power without loss from slip. The cost of a narrow pulley is much less than that of a wide pulley; two 20-in. belts, working compound, will transmit more power than one 40-in. belt working from a wide pulley. The author gives a number of examples in which compound belt-driving has been applied with satisfactory results. To get perfect belt-driving a great deal depends on the form of the pulleys. Much loss of power and destruction of belting is due to the high convexity with which most pulleys are made. A convexity of $\frac{1}{16}$ of an inch is sufficient for pulleys 6 in. wide and under; the smaller or driven pulley may be made perfectly flat. The author discusses belt versus rope driving, and expresses his opinion strongly in favour of belts. A. S.

DYNAMOS, MOTORS, AND TRANSFORMERS.

1089. *Standardising of Generators, Motors, and Transformers.* (Amer. Instit. Elect. Engin. 15. pp. 71–100, 1898.)—This is a discussion at the American Institution of Electrical Engineers on the advisability of having all dynamos, transformers, etc. of standard sizes so as to render pattern making less laborious and the manufacture of the machines cheaper. The question was referred to a select committee. W. G. R.

1090. *Armature Reactions.* **C. A. Bessey.** (Elect. Engin. N. Y. 25. pp. 511–512, 1898.)—This is an experimental investigation of armature reaction in simple shunt and compound wound dynamos. The machine experimented on was a 15 kilowatt, 125 volt Edison bi-polar dynamo run at 1600 revolutions per minute. The induction distribution was obtained by measuring

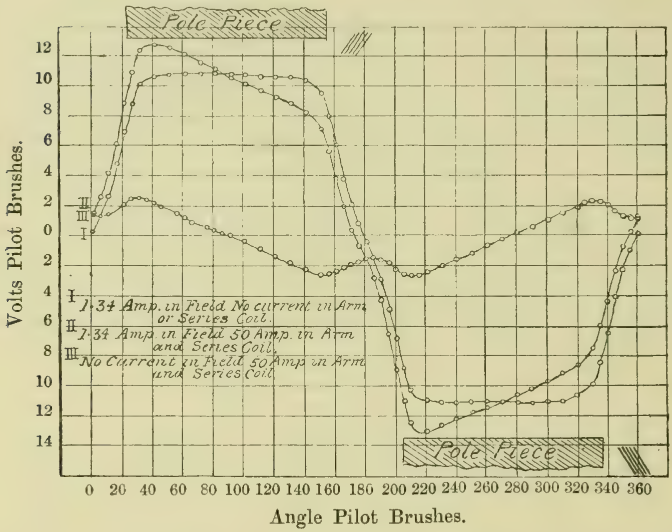
Fig. 1.



with a Weston voltmeter the E.M.F. between two steel pilot brushes bearing on the commutator and shifted into different angular positions. Wirt collector brushes were used, and after being given proper lead for non-sparking at 50 amperes, were fixed in this position through the experiments.

In the accompanying figures, curves I shows the induction distribution with field excited and no current in the armature; curves II, the induction distribution with field excited and 50 amperes in the armature; curves III, field magnetism reduced to

Fig. 2.



zero and 50 amperes in the armature. Figure 1 refers to the machine run as a simple shunt, and figure 2 to it as a compound dynamo. W. G. R.

1091. *Single Phase Induction Motor.* **C. P. Steinmetz.** (Amer. Instit. Elect. Engin. 15. pp. 103–183, 1898.)—When running at or very near synchronism, the magnetic field of the single-phase induction motor is identical with that of the polyphase motor, since in a turn wound at right angles to the primary winding, at synchronism an E.M.F. is induced equal to that induced in a turn of the primary winding, but differing therefrom by 90° in phase.

The greater portion of this paper is devoted to starting devices. All starting devices of the commutatorless single-phase induction motor consist in the production of a component of magnetic flux displaced from the axis of polarisation of the induced currents, and may be grouped into three classes, viz. :—

1st. *Phase-splitting Devices*, in which the primary system is composed of two or more circuits displaced from each other in position, and combined with impedances of different inductance-factors so as to produce a phase-displacement between them.

2nd. *Induction Devices*, in which the motor is excited by a combination of two or more circuits which are in inductive relation to each other. This mutual induction between the motor circuits can either take place outside the motor in a separate phase-splitting device, or in the motor proper.

3rd. *Monocyclic Starting Device.*—An essentially wattless E.M.F. of displaced phase is produced outside of the motor, and used to energise a cross-magnetic circuit of the motor, either directly by a special tease-coil on the motor, or indirectly by combining this wattless E.M.F. with the main E.M.F., and thereby driving a system of E.M.F.'s of approximately three-phase or any other relation.

Each of these types of starting devices is discussed in detail, the object being to enquire into the starting torques and the acceleration produced. The author concludes that of all single-phase induction-motor starting devices, the monocyclic device most nearly reproduces in starting and accelerating the conditions of the polyphase motor. In the discussion which followed the reading of the paper, the question of the legitimacy of the assumption of sine currents and E.M.F.'s arose. The general opinion was that the results obtained on that assumption agreed so nearly with actual practice as to justify its use. W. G. R.

1092. *Asynchronous Motors.* **E. J. Brunswick.** (Électricien, 15. pp. 305–307, 321–324, and 340–344, 1898.)—The condition that the torque in a polyphase motor should be independent of the speed of the rotor is

$$R = pL;$$

where R is the resistance and L the coefficient of self-induction of each rotor circuit, and p is 2π times the frequency of the induced currents. From this it follows that a uniform torque could be obtained as the rotor runs up to speed by having variable resistances in the rotor circuits and gradually cutting them out as the speed increases. Such a process involves rubbing contacts and probability of sparking, both of which are undesirable. In the Boucherot system the same end is attained by different means. The stator, instead of being wound in the ordinary fashion, consists of two distinct windings, one of which is fixed and the other is capable of rotating through an angle representing half a period of the supply current. Thus in a four-pole motor the possible angular rotation is 90 degrees. The movable part of the stator assumes the displaced position at start, and is rotated back again on full speed being attained. The rotor is of special design, but still consists of short-circuited bars without any rubbing contacts whatever. Three types of motors are constructed according as the motor is to be placed in an accessible place or not, or in the case where the conditions require a minimum number of conductors.

W. G. R.

1093. *Thickness of Transformer-Plates.* **W. Dittenberger.** (Écl. Électr. 15. p. 362, 1898.)—Loppé has recently (Écl. Électr. 11. p. 548, 1897) given the following formula for the loss per cubic cm. of iron in the core of a transformer:

$$W = \alpha \frac{B'^{1\cdot 6}(e+\epsilon)^{1\cdot 6}}{e^{1\cdot 6}} + \beta B'^{2}(e+\epsilon)^{2},$$

where e is thickness of plates, ϵ that of insulation between them, B' = magnetic flux per sq. cm. of section of core, and α and β are constants. Using this expression, Loppé graphically determines the value of e which will render B' a maximum for given values of W and ϵ. The author solves this problem analytically, and finds that the required value of e is given by the equation

$$W = \alpha \cdot \frac{\epsilon_4}{e^{12}} \left(\frac{4\alpha}{4\beta}\right)^{4} \cdot \left(1 + \frac{4}{5}\,\frac{\epsilon}{e}\right),$$

an approximate solution of which may be easily obtained. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1094. *Plant of the Ellicott Square Building.* **F. L. Wilson.** (Elect. World, 31. pp. 519–522, 1898.)—A feature of interest in the electrical plant of the Ellicott Building at Buffalo is the system of regulation of the forced draught. The system, due to Mr. John Beckman, depends upon the action of three valves. A regulating valve is placed on the inlet-pipe to the engine which drives the blower. This valve is so arranged as to open and increase the speed of the blower engine as the pressure of the steam in the boiler falls below the desired point, and to close and decrease the speed as the pressure rises. A pressure-reducing valve is placed in series with the regulating valve to limit the speed of the fan, and to set the draught pressure in such a manner as to produce the most efficient combustion and create under the boiler the greatest heat that the water is capable of absorbing. The stack damper is set to hold back this heat so that the escaping gases do not leave the uptake at more than 100° above the temperature of the steam. When the steam pressure in the boiler has reached the desired point the regulating valve cuts off the direct supply of steam to the blower engine, and the fan would stop but for the introduction of a by-pass consisting of a small pipe supplied with a reducing valve. By this means steam just sufficient to keep the fan revolving, and at a low pressure of 6 or 8 pounds, is supplied to the engine. The following results of tests on the working of the plant are worthy of notice :—

Water evaporated per pound of coal	6·77
Equivalent from and at 212°	8·18
Equivalent water per pound of combustible from and at 212°..........................	9·03
Commercial horse-power of boilers, based on 30 pounds	250·00
Builder's rating	250·00
Average amount of steam supplied to electric-light engine per electric horse-power hour (pounds)...........................	36·73
Average output for 8760 hours (365 days), kilowatts............................	77·99
Heaviest load, kilowatts	260·00
Average coal per ampere-hour, pounds (water supplied at 56°)	0·84
Average coal per ampere-hour (water supplied at 183°)	0·75

W. G. R.

1095. *High Voltage Transmission Lines.* **S. H. Dailey.** (Amer. Electn. 10. pp. 194–197, 1898.)—This is an article on the

practical details to be noted in the erection of a high-voltage transmission line. Special attention is paid to safety devices, and the author recommends that a barb wire should run the entire length of the line and grounded every half mile. W. G. R.

1096. *Protection of Three-Wire System.* **E. Oxley.** (Elect. Engin. N.Y. 25. pp. 483–484, 1898.)—The author refers to the trouble which may be caused to that side of a three-wire system which has the smaller load due to a sudden and considerable increase in the potential reproduced upon that side, such increase being produced by opening the neutral, or balancing wire, by the blowing of its fuse. The increase in potential from this cause may reach a point where it is almost double the voltage that should normally exist. The injury to incandescent lamps, fan motors, and enclosed arc lamps may be considerable. The "over-fusing" of the neutral wire, which has come to be a common practice among wiremen and others, came into existence, and owes its prevalence to the fact that it has hitherto been the only known expedient for avoiding disturbances of this character. This practice of "over-fusing" the neutral wire is directly contrary to the rules of the Board of Fire Underwriters. The author points out that there is a far greater menace to property, however, in the fact that the abnormal tension on the underloaded side of the system, upon the blowing of the neutral fuse, develops weak spots in the wiring; or if such places already exist, the insulation quickly gives way under the strain, and destructive fires may be the direct result. To remove the possibility of such disturbances occurrng, the author has devised a simple safety attachment for a three-pole switch, of which illustrations are given. The principle of its operation consists in automatically opening the switch by the action of a spring immediately upon the blowing of the neutral fuse, the switch being maintained in its closed position by a latch or catch. This latch is released, or withdrawn from its locking engagement, by the attraction of a small electromagnet having its terminals connected to the ends of the neutral fuse. So long as the fuse remains intact no current flows through the windings of the magnet, as the potential at its terminals is only that due to the drop in voltage in the neutral fuse itself. Upon the blowing of the fuse, however, the potential between the points of connection immediately rises, causing current to flow through the magnet coils, thus energising the magnet sufficiently to enable it to release the catch. Although the winding of the magnet is in parallel with the neutral fuse, it does not in any degree affect the carrying capacity of the latter, as the resistance of the coils is great relatively to that of the fuse. The opening of the switch follows so closely upon the blowing of the fuse that it is said to be practically impossible to distinguish the interval which separates the two occurrences. L. J. S.

1097. *Long-distance Transmission Experiment at Ogden.* (Elect. Rev. N. Y. 32. p. 287, 1898.)—This experiment was carried out at Ogden, Utah, in order to ascertain the limits within which high-voltage currents may be used commercially. The experiment was made by F. O. Blackwell over the lines which connect the power station at Ogden with the distributing circuits at Salt Lake City, the complete transmission circuit being 73 miles long over three No. 1 wires. The amount of power transmitted amounted to 1000 horse-power, and the transmission voltage at times reached 30,000 volts. The current on the return was delivered to resistance-vats at the power-house, consisting of three wooden tanks. This power was transmitted with a loss of only nine per cent., including four per cent. loss in the two sets of transformers. Continuing the experiment, part of the Salt Lake City station load was run from Ogden with current at 24,000 volts. This was supplied to about 500 horse-power in synchronous motors and lights for two days under severe climatic conditions without the slightest hitch. W. G. R.

1098. *St. Anthony Falls Water-Power Plant.* (Amer. Electn. 10. pp. 185–192, 1898.)—These works were recently constructed by the St. Anthony Falls Water Power Co., and on completion were leased to the Twin City Rapid Transit Co., to furnish power for street railways in Minneapolis and St. Paul, supplanting the steam-driven machines at first installed. The site of the generating works is in Minneapolis, just below the St. Anthony Falls on the Mississippi. A V-shaped dam, with a crest about 1000 ft. long, has been constructed of cut granite, and gives a maximum head of 22 ft.; it is provided with sluices, waste weirs, etc., of which a full description is given. The power-house, which forms part of the dam, contains room for ten 700 K.W. sets, seven of which are now installed, and two smaller sets for supplying exciting current. The main turbines consist of two pairs of 42-in. horizontal water-wheels on the same shaft directly connected to a generator; the sluices for each set are regulated by a governor driven by belting off the generator shaft. In the generating station there are already installed five three-phase alternators yielding 700 K.W. at 3450 volts with frequency about 35; two 700 K.W. direct-current dynamos feeding a 500-volt railway circuit direct; and two 100 K.W. 6-pole exciters. There are three substations: to No. 1, about 1¾ miles distant, current is transmitted at 3450 volts and actuates two 600 K.W. rotary converters; these are of the 8-pole type giving 580 volts on the direct-current side at 530 revs. per min. No. 2, situated about 4½ miles from the main station, contains one rotary converter of the same type supplied at the same voltage. No. 3, ten miles distant, is supplied at 12,000 volts, and contains two similar converters. Twenty-one 233 K.W. transformers are installed, six at the main station and fifteen in the substations. The transmission is by paper-insulated lead-armoured triple conductors laid underground, two leading to

substation No. 1, and one each to the other substations. The paper is illustrated by eighteen views of different parts of the plant. M. G. W.

1099. *Booster System in Electric Railways.* **J. L. Woodbridge.** (Frank. Instit. Journ. 145. pp. 374–385, 1898.)—Booster is any electro-magnetic generator whose armature is connected in series with a feeder with the object of compensating for drop of voltage in that conductor due to the current which it is transmitting. In lighting and traction work it has proved very useful, rendering it possible to take up loss in feeders too long to form part of the main system. In every case of heavy drop in feeders, boosting involves difficulties in keeping uniform voltage along the whole line. It is practically equivalent to a very strong over-compounding, reinforcing the system only in the needy branches. Any spare generator in the station can be used for the purpose. A "compound series booster" is simply an ordinary compound-wound constant potential machine, connected by a double-throw switch, to serve (1) as a booster when required, or (2) as an ordinary generator. The shunt-coils are connected in parallel with each other and with a certain portion of the feeder, so that a small but constant percentage of current circulates through them, and, like the series coils, the magnetising force is proportional to the load, obtaining thus the series effect from both shunt and series windings. The variation of voltage is carefully gone into, and its causes inherent in the booster machine. (1) Saturation of field-magnets. When using a machine on hand with this fault, remedy it by limiting the load, or providing sufficient copper in the feeder to limit the maximum voltage required and range of magnetisation. (2) Hysteresis effects have little importance in railway work owing to the peculiar nature of the variations of load. (3) Sluggishness, due to inductance and Foucault currents. The effect of high inductance of shunt-fields are rather more serious, and this is minimised by limiting the extent of their magnetising force by dividing them up in parallel, thus tending to check the portion which will lag. As a rule it is not advisable to operate the booster continually, but to put enough copper to carry ordinary loads satisfactorily, reserving the booster for times of excessive traffic. But with a low price of fuel it pays to use a booster for as much as 18 hours a day. The booster system, if used with skilled judgment, may save a large expenditure in copper at the cost of an amount of wasted energy that is well within the limits of economy. P. D.

1100. *Accumulator Traction.* (Electrician, 41. pp. 9–10, 1898.)—An abstract is given of a report drawn up by a deputation of the Blackpool Corporation after visiting various Continental systems of electric traction. The estimated cost is given of supplanting the present conduit system by accumulator traction. The rolling-stock consists partly of double-bogie cars weighing 11 tons and

partly of smaller cars weighing $7\frac{1}{2}$ tons. The relative costs of maintenance work out to the following figures :—

Overhead system	£600
Conduit system, cost during 1897 .	2238
Accumulator system............	2799

W. R. C.

1101. *Accumulator Road Traction.* **J. T. Niblett.** (Mech. Eng. 1. pp. 520–531, 566–568, 607–609, 628–629, 1898.)—A variety of forms of storage-cells—both obsolete and in present use—are described, and some elementary data given concerning the calculation of internal resistance, efficiency, and so forth. Many particulars as to the construction and working of the electric cabs now running in London and in New York are also given. The former carry 40 Faure-King cells having a total weight of 14 cwt. and an output of 170 ampere-hours when discharging at a 30-ampere rate. One motor of the Johnson-Lundell type is used, capable of normally developing 3 horse-power, and provided with double windings on both fields and armature for the purpose of obtaining the various speeds. The latter contain 44 3-plate cells of the chloride type, whose total weight is 900 lbs. and capacity 100 ampere-hours at a 21-ampere rate. Two motors, each of 1·5 horse-power at 800 revolutions, are employed. E. J. W.

1102. *Electric Traction.* **G. Pellissier.** (Écl. Électr. 14. pp. 449–456; 15. pp. 63–67, 140–143, 187–189, 1898.)—The author gives an account of various patents relating to electric traction. Among the number are included the Blackburne and Spence system of traction, the Priest and Merrick pneumatic series-parallel controller, the MacElroy truck, the arc-trolley of the Industrie Électrique Company, and that of Siemens. Some account is given of the New York conduit-lines. The author then describes the conduit systems of Griffin and Small; Hecker; Allen; Nigel, Harington, Balfour, and Smith, in which a small trolley within the conduit is magnetically attracted by the car and thus caused to run with it, making alive the various sections of a rail on the surface; of Siemens; and of Arno and Caramagna. W. R. C.

1103. *Counterweight System in Electric Cable Tramways.* (Street Rly. Rev. 8. pp. 286–288, 1898.)—The grade of the tramway begins at 5 per cent., increasing gradually to 16 per cent., then falling to 4 per cent. The vertical height attained is more than 100 ft. In going up- or down-hill, each passenger-car is controlled by a grip-car immediately below it on the grade; the grip-car is attached by a gripping device to the cable, and a counterweight running in a tunnel half the length of the tramway balances the weight of the cars. There are thus no counterweight cable fastenings and draw-bar connections. A number of drawings are given illustrating the mechanical construction of the line.

A. S.

1104. *Electric Street Railways in Baltimore.* **C. B. Fairchild.** (Elect. Engin. N.Y. 25. pp. 569–571, 1898.)—This is a description of the Baltimore City Passenger Railway, which is about to be transformed into an electric line. Formerly the cable cars were operated in trains, consisting of an open grip-car and trailer. The train system still remains; but the open grip-cars have been converted into trailers, and the closed cars used for the grip-car.

W. G. R.

1105. *Best Arrangement of Return Feeders for Traction.* **F. Natalis.** (Street Rly. Journ. 14. pp. 277–283, 1898.)—To tramway engineers the arrangement of the return feeders is an important question. The rails alone are seldom of sufficient carrying capacity for returning the current to the power-station. Large potential differences between two points on the line are not admissable, on account of so-called "vagabond currents," which disturb telephones and scientific instruments, ruin pipes, etc. The local authorities usually insist upon a definite maximum fall of potential on the return circuit. Return feeders are at best expensive; and if their number and locations are unwisely chosen, their cost of construction is considerably increased The author gives a number of formulæ and examples for settling this important question, and concludes this article by stating that, considering what great expenses are often involved, it is well worth the trouble to make use of such formulæ. In these calculations, as well as in many similar ones, many things must of course be left to the judgment of the engineer.

L. J. S.

1106. *Rail-Bonding.* **J. R. Chapman.** (Street Rly. Rev. 8. p. 347, 1898.)—A cast-welded joint in a 56-lb. rail, which had been in use for $2\frac{1}{2}$ years and was worn out, was tested, with the results tabulated below, showing that the conductivity of the joint was practically equal to that of the rail. The joint was afterwards sawn through; a view of the section is given.

Test No.	Average Amperes Flowing.	Drop in 5 ft. with Joint.	Drop in 5 ft. without Joint.	Drop in Volts per 100 Amperes Flowing.
		volts.	volts.	
1.	502·6	......	·047	·00935
2.	508·9	·048	......	·00943
3.	735·8	·065	......	·00883
4.	758·8	......	·069	·00910

Temperature of rail during tests, 80° F.

A. H. A.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

OCTOBER 1898.

GENERAL PHYSICS.

1107. *Theory of Deformation of Metals.* **M. Brillouin.** (Annal. Chim. Phys. 13. pp. 377–404, 1898.)—As a result of microscopical examination and metallurgical investigation, the ordinary metals used in construction are assumed in this memoir to be composed of a great number of very small crystalline elements or grains embedded in a network of viscous matter. The crystalline elements are supposed to be possessed of elasticity but to be deprived of viscosity, whilst the surrounding network is deprived of elasticity. The author then proceeds to show how the laws of permanent deformation follow from this assumption. The present memoir deals with homogeneous deformation. Hooke's law is assumed for the elasticity of the crystals, whilst the linear law expresses the viscosity. The deformations due to the crystalline and viscous components of the metal are then calculated, the former being simply the ordinary elastic deformations, and the latter being obtained by integrating the ordinary equations for a viscous fluid for the form of the network in question. The total deformation is thus shown to consist of a term representing the elastic deformation of the crystalline elements, and a term consisting of some function of $\int_0^t X dt$, (X being the deforming force and t the time), which represents the viscous deformation. The author lays great stress upon the importance of taking account of the time in making experimental tests, especially where stops are made with the specimen under load, and states that many of the irregularities in the results obtained in mechanical laboratories, which have usually been put down to faults in the metal, may probably be accounted for by neglect of this precaution.

The equation obtained for the deformation is then put into the

following form

$$x=\mathrm{KX}+\phi\left(\int_0^t \mathrm{X}dt+\mathrm{A}\right)-\phi\mathrm{A},$$

X being the force and x the length, and A being a constant depending on the initial state of hardness of the metal. For a rapid variation of load without shock the deformation is shown to be elastic, and the coefficient of elasticity is defined as being fixed by the amount of the sudden variation of the deformation when produced without shock. Thus to obtain the coefficient of elasticity it is necessary to measure the initial value of the alteration of the deformation. It is then shown that after a stop of great length under the action of a load, a small deformation effected rapidly without shock is purely elastic. Considering the case of deformation produced at a constant rate, the author shows that the resulting relations agree with the law discovered by M. Bouasse in his experiments upon the torsion of a platinum wire (Comptes Rendus, Feb. 1897). After discussing the case of a cycle performed at a constant rate interrupted by stops under load, the author gives some geometrical illustrations of the foregoing, and concludes by indicating the treatment of torsion and bending and also the influence of temperature and physical properties of the metals on the function ϕ. A. Gs.

1108. *Solar Radiation in the High Alps.* **G. B. Rizzo.** (N. Cimento, 4. 7. pp. 120–130, 1898.)—The formulæ of Pouillet ($Q=Ap^{\epsilon}$), Crova ($Q=A/(\overline{1+\epsilon})^m$), and Bartoli ($Q\epsilon^n=K$), for the quantity of solar heat incident per unit of normal area, though Crova's works best, are all subject to the objection that when the sun is in the zenith ($\epsilon=0$), the values obtained for the solar constant become inadmissible, as they also do with Ångström's binomial formula, $Q=(2{\cdot}568\times0{\cdot}751^{\epsilon})+(10{\cdot}335\times0{\cdot}049^{\epsilon})$. Observations made on the Rocciamelone in the Val de Susa, at different heights, gave on reduction the formula $Q_1=a-b\mu^n$ for the value of the solar radiation considered as zenithal, μ being the mass of air already traversed by that radiation: and the solar constant has a value very near 2·5 small calories per minute and per square centimetre, this value being of course apart from that of any particular radiations to which the upper regions of the atmosphere may be opaque. A. D.

1109. *Surface Tension of Gold.* **G. Quincke.** (Annal. Phys. Chem. 64. 3. pp. 618–619, 1898).—Heydweiller has recently found the specific cohesion of gold to be 6·90 mm.^{2}, and considered Quincke's value, equal to the specific cohesion of water, or roughly $2\times8{\cdot}5$ mm.^{2}, as much too high. Quincke now defends his value and attributes the lowness of Heydweiller's to the one half per cent. impurity which his gold contained; the gold used by Quincke having been perfectly pure. J. B. H.

1110. *Capillary Constants from Drops.* **A. Heydweiller.** (Annal. Phys. Chem. 65. 2. pp. 311–319, 1898.)—The author compares Poisson's, Lohnstein's, and Siedentopf's methods of determining the surface-tension of a liquid from the dimensions of a drop. He then draws up a table, based chiefly on Lohnstein's work, by means of which anyone can calculate, with ease, the specific cohesion of the liquid. He applies this table to certain observations of Quincke and Sieg. A. Gs.

1111. *Hydrogen in Nebulæ.* **J. Scheiner.** (Ast. Phys. Journ. 7. pp. 231–238, 1898.)—It is well known that the spectrum of hydrogen in the nebulæ is different from that in an ordinary vacuum-tube, in the fact that whereas in nebulæ $H\beta(\lambda 4861)$ is well seen, $H\alpha(6561)$ is almost invisible or entirely so; in a tube $H\alpha$ is usually brighter than $H\beta$. $H\alpha$ has so far only been observed in one nebula (G.C. 4390), by Keeler, and then very faintly. Experiments in the laboratory show that by reduction of intensity the spectrum in a vacuum-tube may be reduced to $H\beta$ in the green-blue. The conditions present in case of nebulæ are (1) extreme attenuation of particles, and (2) temperature probably approaching absolute zero. The first condition has been imitated by examining the hydrogen in large wide tubes very highly exhausted, and excited by feeble discharges. Throughout these proceedings it is found that as intensity is reduced, $H\alpha$ disappears first, leaving $H\beta$ only visible. The second condition has been experimented on by Koch (Wied. Ann. 38. 1889), who used wide Geissler tubes kept at a temperature of $-80°$ to $-100°$ C. by means of solid carbonic acid and ether. No appearance of any change in spectrum could be detected. The author has since repeated this experiment with temperatures as low as $-200°$ C., using liquid air. His observations entirely confirm those of Koch in that no change was seen. The phenomenon was then thought to be possibly physiological, and a number of experiments are described which render this probable. He found that with the same tube he could obtain a gradual change of the $H\alpha$ line from being brighter than $H\beta$, to equality and then completely vanishing, by simply decreasing the light emitted by the tube. From this he concludes that the appearance is purely physiological, and if this is so, great importance must be attached to it, as it is impossible to base any conclusions on the physical constitution of the nebulæ from this peculiarity of the spectrum of hydrogen. C. P. B.

1112. *Hoffmann's Formula for Oceanography.* **F. v. Wrangell.** (Annal. Phys. Chem. 65. 1. pp. 237–240, 1898.)—In this paper the author draws attention to a false formula in connection with deep-sea currents, which was first printed by Hoffmann in his work 'Zur Mechanik der Meeresströmungen,' and has been copied from there into several other treatises on the subject. Zöppritz showed that in a mass of water of unlimited depth and infinite extension, if the surface were set in motion with a uniform velocity

w_0, then the depths to which any particular velocity less than w_6 would have penetrated after certain intervals of time are proportional to the square roots of these intervals. The formula giving the velocity v at time t, at depth x, is

$$v=w_0\left\{1-\frac{2}{\sqrt{\pi}}\int_0^{x/2\sqrt{ut/k}} e^{-z^2}dz\right\},$$

where $u=$ specific gravity, and $k=0\cdot0144$ the viscosity of water. This formula Hoffmann transformed into

$$\sqrt{t}=1736\,.\,h\,.\,\frac{1}{n},$$

where h is the depth and $\frac{1}{n}$ the velocity, the surface velocity being taken as unity. Hoffmann's formula is shown not to be even approximately correct by taking particular values and evaluating the above integral. J. B. H.

1113. *Superficial Conducting Films.* **F. Braun.** (Annal. Phys. Chem. 65. 2. pp. 365–367, 1898.)—Following up a previous research, the author experimented on surfaces of rock-salt, and found that the current became stationary in a comparatively short time (about 2 min. over concentrated sulphuric acid). He concludes that for really homogeneous and continuous conducting films there is no polarisation; and that conversely the absence of polarisation is a test for the presence of such a film. The film which forms upon rock-salt shows a smaller vapour-tension than a saturated solution of sodium chloride; and the thickness of the film is regulated by the tension of aqueous vapour prevailing at the time. G. B. M.

1114. *Harmonic Analysis.* **S. Berson.** (Écl. Électr. 15. pp. 287–289, 1898.)—A graphical method applicable to periodic functions containing only odd harmonics, and worked out with special reference to a function containing no higher harmonics than the 5th. Let the function be $E_x=S_x+C_x$, where

$$S_x=a_1\sin x+a_3\sin 3x+a_5\sin 5x,$$

and

$$C_x=b_1\cos x+b_3\cos 3x+b_5\cos 5x.$$

The first step consists in splitting E_x into its sine and cosine terms respectively. Since on substituting $180^\circ-x$ for x we obtain $E_{180^\circ-x}=S_x-C_x$, it follows that

$$S_x=\tfrac{1}{2}(E_x+E_{180^\circ-x}),$$

and

$$C_x=\tfrac{1}{2}(E_x-E_{180^\circ-x}).$$

Let in fig. 1 the full-line curve represent E_x, plotted in polar

coordinates. Take any two points P and Q, such that OP and OQ are equally inclined to the axes, and from M, the middle point of the intercept P′Q′ on the vertical axis by the perpendiculars

Fig. 1.

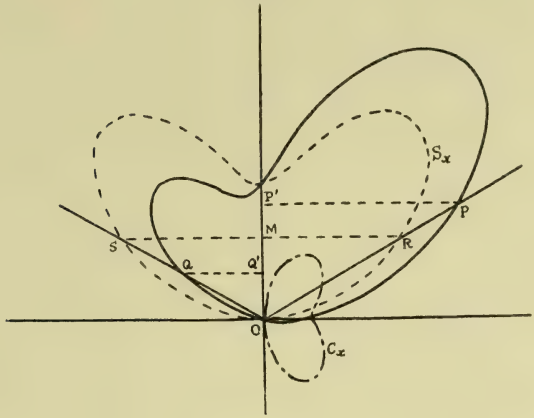
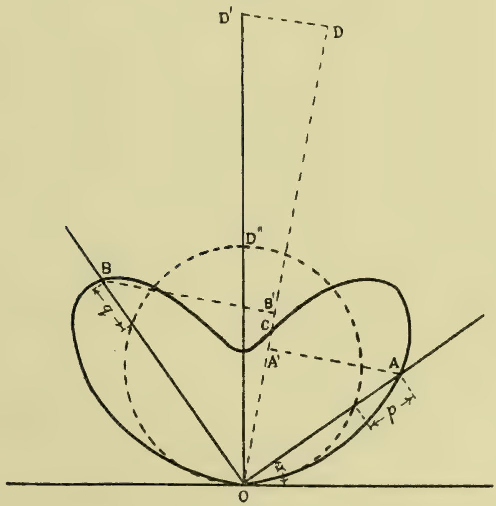


Fig. 2.



from P and Q, draw a perpendicular to intersect the radii vectores to P and Q in R and S respectively. Then R and S are two points on S_x; by choosing a sufficient number of points, the S_x curve (shown dotted) may be drawn. From this the C_x curve (shown chain-dotted) is at once deduced. In order to effect the analysis

of either component curve, say S_x, into its simple harmonic terms, the equation

$$2a_1 \sin(45^\circ + x) = S_x/\sqrt{2} + S_{90^\circ+x}/\sqrt{2} + S_{45^\circ+x}$$

is made use of to evaluate the principal term. In fig. 2, the full-line curve represents S_x. Take two points, A and B, separated by 90°, and project them on the bisector of the right angle. Then $OD = OA' + OB' + OC$ gives $2a_1 \sin(45^\circ + x)$. From D draw DD′ at right angles to OD, and intersecting the vertical axis in D′. Then $OD'' = \frac{1}{2}OD' = a_1$, and a circle constructed on OD″ as diameter gives the first harmonic term. To obtain a_3 and a_5, we have the equations (fig. 2):

$$p = a_3 \sin 3x + a_5 \sin 5x, \text{ and } q = -a_3 \cos 3x + a_5 \cos 5x,$$

from which we obtain:

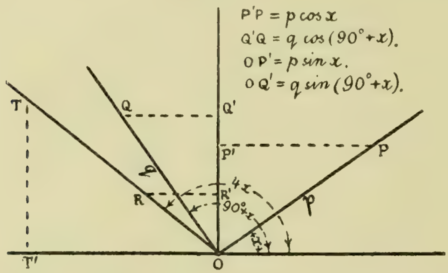
$$a_3 + a_5 = [p \cos x + q \cos(90^\circ + x)]/\sin 4x,$$

and

$$a_3 - a_5 = -[p \sin x + q \sin(90^\circ + x)]/\cos 4x.$$

The construction shown in fig. 3 enables us to determine a_3 and a_5.

Fig. 3.



By laying off $OR' = P'P + Q'Q = P'P - QQ'$ and erecting a perpendicular at R′ we get $OR = a_3 + a_5$. Similarly we find $OT = a_3 - a_5$, where $OT' = OP' + OQ'$. Thus a_3 and a_5 are determined. To secure accuracy, the above constructions should be repeated for *a* number of points on the original curve, and the mean result taken. A. H.

1115. *Properties of Nickel-Steels.* **C. E. Guillaume.** (Journ. de Physique, 7. pp. 262–274, 1898; also Comptes Rendus, 126. pp. 738–740, 1898.)—The characteristics of various compounds of iron and nickel are considered. With regard to *magnetic properties*: nickel-steels containing besides iron and nickel only small quantities of carbon, silicon, and manganese, fall into two distinct categories. The first containing from 0 to about 25 % of nickel, and which seem comprised pretty accurately between the formulæ Fe and Fe_3Ni, are "irreversible" in the sense that at one and the same temperature they can exist in two essentially different states, according to the preceding cycle of temperatures. When these alloys are heated they lose their magnetism gradually between

two temperatures, which are comprised for all the alloys between dull red and cherry red. When they are cooled they pass again through the same temperatures without becoming magnetic, and only reacquire their first condition at a temperature lower than those between which the loss of magnetism occurs. The return to the magnetic state takes place for an alloy with 24 °/₀ nickel a little below zero. The presence of chromium lowers the temperature at which the return takes place. The steel with 22 °/₀ nickel and 3 °/₀ chromium remains non-magnetic even in liquid air. Steels with more than 25 °/₀ nickel are "reversible," and possess at each temperature magnetic properties which to a first approximation depend only on the actual temperature. The *expansion* of the material has been observed by comparison with a brass scale. The phenomenon noticed by A. Le Chatelier has been confirmed: the expansion for the same alloy is much more feeble in the magnetic state than in the non-magnetic state. The transformation is gradual as regards expansion as well as regards magnetism, and the same alloy may possess any coefficient of expansion between two determined limits according to its degree of transformation. In one of the extreme states the expansion is a little greater than that of brass, in the other it is lower than that of ordinary steels. At ordinary temperatures the steels of the second category possess a coefficient of expansion which varies continuously with the composition. Steels containing 35 to 36 °/₀ of nickel expand ten times less than platinum. Other *mechanical* constants and their changes are also referred to. The alloys of the first group in passing from their non-magnetic state, where they are relatively soft and easily deformed, to the magnetic state when they become hard and very elastic, undergo a diminution of the modulus of elasticity. The nickel-steels possess a high specific resistance, and the transformations which they undergo do not seem to affect the variations of the electric resistance, the curve of change is an ordinary one. The variation of resistance with temperature seems to be independent of the variations of volume. For the alloys of the first sort the passage to the magnetic state takes place with increase of volume. A chemical origin is suggested for the peculiarities of behaviour, and it is supposed that definite chemical compounds tend to be formed. The experiments show that the irreversible nickel-steels can possess between extended limits of temperature an indefinite number of states of equilibrium, which they keep almost without modification so long as the alloy does not cut, at low or high temperatures, two curves of transformation along which all its properties change gradually and simultaneously. They possess besides unstable states of equilibrium which can be broken quickly, and to which an almost instantaneous transformation puts an end. See also Phys. Soc. Abstracts, Nos. 469 and 517, 1897.

J. J. S.

LIGHT.

1116. *Astronomical Refraction.* **P. Pizzetti.** (Atti R. Accad. Sci., Turin, 33. pp. 137–151, 1898.)—Bessel's theory is based on the hypothesis that the temperature t of the air varies with the height h above the earth according to the equation

$$\frac{1+\epsilon t}{1+\epsilon t_0} = e^{-k\frac{h}{a+h}},$$

where t_0 is the temperature at the earth's surface, ϵ the coefficient of thermal dilatation of air, a the mean radius of the earth, and k a constant. But his formulæ when reduced to figures give a fall of 1° C. for 815 metres of ascent at the earth's surface; which is inadmissible. Besides, it follows from Bessel's formulæ that the fall of temperature is nearly the same whatever the initial temperature t_0, whereas it is really more rapid the higher the value of t_0. The author starts from Mendelejeff's law (deduced empirically from Glaisher's observations) that

$$t = a + bp,$$

where t and p are the temperature and pressure, and a, b are constants ($a = -36°$). He then proceeds by analysis (which does not lend itself to abridgment), and finds that near the earth the fall is 1° per 307, 222, 174, 150, 134 metres of ascent when the earth-temperatures are respectively $-10°$, 0°, 10°, 20°, 30°. The pressure and the temperature both fall off more and more slowly as the height increases. The author reaches an expression for the refraction, of the form

$$\mathrm{R} = \frac{\alpha\sqrt{2\gamma}}{1-\alpha}\sum_1^\infty \mathrm{C}_n\sqrt{n}\,.\,e^{\mathrm{T}^2}\int e^{-x^2}dx,$$

which gives results in harmony both with the observed refractions and with the observed variations in temperature. A. D.

1117. *Phase-Reversal Zone-Plates and Diffraction Telescopes.* **R. W. Wood.** (Phil. Mag. 45. pp. 511–522, 1898.)—It was demonstrated by Soret that if we describe on a plate of glass a series of circles with radii proportional to the square roots of the natural numbers, and render the alternate rings opaque to light, the plate will have the property of bringing parallel rays of light to a focus like a condensing-lens. The opaque rings cut off the disturbances from the alternate Huyghens zones, which by destructive interference with the waves from the other zones produce the phenomena of shadows. Lord Rayleigh has pointed out that if it were possible to provide that the light, instead of being cut off by the alternate zones, should suffer a phase-

reversal, the illumination at the focus would be four times as great as with the Soret form of plate. This has been accomplished by preparing zone-plates with rings of thin transparent gelatine of such thickness as to retard the light-waves one-half wave-length, thus securing the required phase-reversal. The plates produce much more brilliant images than the usual form; and by using one of five-feet focus as the objective of a telescope, some of the larger lunar craters could be made out. The plates were made by preparing a drawing of 230 concentric rings of the requisite diameter, blackening the alternate spaces, and reducing the drawing to the size of a shilling by means of photography. From the negative, prints were made on plate glass, sensitised with an exceedingly thin film of bichromatised gelatine. On washing in warm water, the rings unaffected by light were dissolved away. Smaller plates of six inches focus were prepared by photographing the original with a microscope objective; and a number of photographs of winter landscapes were made, using the zone-plate instead of the camera lens. These photographs have a peculiar quality, and some are very artistic; but much has been lost by reproduction. The originals somewhat resemble charcoal sketches. Where a mass of twigs and branches appear against the sky, there is a background of shadow over the whole, although the definition is fairly good. The ratio of aperture to focus was about F 32, much smaller than in the case of pin-hole photography.

Phase-reversal plates were also made by making the alternate zones of silver and mounting the plate on the reflecting surface of a right-angle prism. These plates operated by reflection, the reversal of phase being introduced by the metallic and total internal reflection.

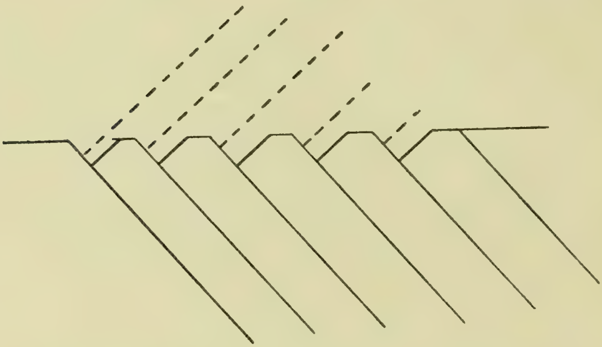
With the paper is a reproduction in black-and-white of the original drawing, from which anyone with a camera can make zone-plates either of the Soret or phase-reversal type. AUTHOR.

1118. *Spectroscope without Prisms or Gratings.* **A. A. Michelson.** (Astr. Phys. Journ. 8. pp. 37–47, 1898.)—The author gives a complete description of the instrument and its theory, of which he wrote a short preliminary note in the Am. Jour. Sc. for March 1898 (see Abstract No. 754). The resolving-power of a grating, being proportional to the product of the total number of lines by the order of spectrum observed, may be increased by increasing either of these factors. Hitherto it has been the first factor, the number of lines, which has received attention; but the author now brings forward a method of using the second, viz. increasing the order observed, with great efficiency.

The difficulties in the way of using high orders in spectra have been very great, as with the ordinary form of grating the intensity very rapidly diminishes as the order is raised, and the *accuracy* of ruling is very influential. It seemed to him quite possible to construct gratings which would throw a considerable percentage

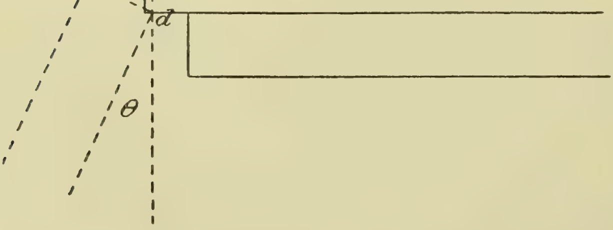
of the incident light into high orders of spectra—say, the hundredth,—to do this it being necessary that the grating-space should be of the order of a *hundred waves*, *i. e.* about *twenty* to the millimeter, instead of a *thousand* as at present. The lines would have to be drawn with no more accuracy than before, and in addition the grating could be made in less time, and therefore temperature and local changes would have much less injurious effect than at present during the ruling operations.

Fig. 1.



The author's first idea was to build up a grating by equal thicknesses of optical glass placed in a series of steps as in fig. 1, the whole being used as a reflection-grating, the grating-space being the distance by which each step is set back from its

Fig. 2.



neighbour. In this form, however, he found great optical difficulties, especially in joining the successive steps so that there should always be the same distance between each pair. By using

the arrangement for transmission, however, this difficulty is removed; and the only difficulty remaining is that of making a considerable number of plane-parallel plates of the same thickness, to an order of accuracy of only one-fourth that required by other methods, and only one-tenth if the other medium be oil or water instead of air. A striking feature of the idea is the small number of plates required to give a resolving power comparable to that of the best fine-ruled gratings.

Let *abd* be one step in the series of plates, and let $ab=s$ and $bd=t$. If m is the order of spectrum observed,

$$m\lambda = \mu \,.\, bd - ac,$$

or

$$m\lambda = \mu t - t\cos\theta + s\sin\theta,$$

$$\frac{d\theta}{d\lambda} = \frac{m - t\dfrac{d\mu}{d\lambda}}{t\sin\theta + s\cos\theta},$$

$$\frac{d\theta_1}{dm} = \frac{\lambda}{t\sin\theta + s\cos\theta};$$

and if $\delta\theta$ is the displacement corresponding to $\delta\lambda$, and $\delta\theta_1$ that corresponding to $\delta m=1$, assuming Cauchy's formula

$$\mu = a + \frac{b}{\lambda^2},$$

and taking the approximate value of

$$m = \frac{(\mu-1)t}{\lambda},$$

we have

$$\frac{\delta\theta}{\delta\theta_1} = [(\mu-1)+2(\mu-a)]\frac{t}{\lambda}\cdot\frac{\delta\lambda}{\lambda}.$$

For flint glass the coefficient of $\frac{t}{\lambda}$ is approximately equal to *unity*; so that if

$$\frac{\delta\lambda}{\lambda} = \cdot 001,$$

as in the case of the two sodium-lines, and $t=5$ mm. $=10{,}000\,\lambda$, then

$$d\theta = 10\, d\theta_1;$$

that is, the sodium-lines would be separated by ten times the distance between the spectra.

The resolving power of such a combination is mn, just as in the case of gratings; so that with but *twenty* elements 5 mm. thick, and hence $m=5000$, the resolving power would be 100,000, which is about equal to that of the best gratings. The experiment was first tried with but *seven* elements; but even with this the Zeeman effect was easily detected when the sodium-lines were placed in a

magnetic field. It is important to note that the resolving power is independent of the *number* of plates, but depends on the *total thickness*, the advantage of a larger number of plates being the greater separation of the spectra.

A spectroscope on this plan has been constructed in the Ryerson Physical Laboratory and is illustrated in the paper. This has twenty elements, each plate being 18 mm. thick, their widths diminishing from 22 mm. to 2 mm., the successive retardations produced being of the order of 20,000 waves. It is then evident that practically all the light can be concentrated in one spectrum, the only losses being due to reflection and absorption, and these are probably less than in either gratings or prisms of equal resolving power.

An interesting and extremely valuable method of testing the plates for parallelism and flatness is given in the paper, which is based on the use of interference-bands shown with monochromatic light (in this case the green radiation of mercury). With this the plates can be worked to an accuracy corresponding to one-eightieth of a wave, which will fulfil all likely requirements.

As a test of the performance of the echelon spectroscope, the author gives a series of measurements of the Zeeman effects on several different radiations, the results being very similar to those he has already obtained by other means. The theoretical resolving power of the instrument illustrated is about 300,000, which he finds slightly too low to examine several radiations for complexity; and his next step is the building of a spectroscope having *five* times the resolution of the present one. C. P. B.

1119. *Rotatory Power of Quartz in the Infra-red.* **Dongier.** (Paris Soc. Franç. Phys., Bull. 105. pp. 1–4, 1898.)—The method of measurement is described. The formula proposed is

$$\rho = (An^2 - B)/\lambda^2 + c/(\lambda - 3{\cdot}2)^2.$$

M. Carvallo, whose formula is

$$\rho\lambda^2 = (An^2 - B) \text{ simply,}$$

pointed out that the proposed formula would make the rotatory power infinite for $\lambda = 3^{\mu}{\cdot}2$, which was very unlikely; and that it would meet requirements to make the equation

$$\rho\lambda^2 = An^2 - B + C\lambda^2,$$

where C is 0·240 for M. Dongier's quartz, but would vary with the samples. M. Carvallo also dealt with Becquerel's law of magnetic rotatory dispersion,

$$\rho = -K\lambda \,.\, dn/d\lambda,$$

and showed that by bringing it to the form

$$\int_{\lambda_0}^{\lambda_2} \rho d(\log \lambda) = -\mathrm{K}(n_1 - n_0)$$

it involved measurable terms, and on plotting these out the formula was found to agree fairly well with observations. A. D.

1120. *Infra-red Dispersion of Quartz.* **E. Carvallo.** (Comptes Rendus, 126. pp. 728–731, 1898.)—Measurements are given of the indices of refraction of quartz: these were made with the aid of a prism of quartz and of a thermoscopic apparatus for the infra-red part. The observations are stated to be of great precision, and are given to five places of decimals. A simple numeration of the fringes gives an indication of the difference of phase, ϕ, established between the two rays by the quartz-plate. These data allow the wave-length, λ, of the fringes used as lines of reference to be calculated from the formula

$$\lambda = \frac{(n'-n)e}{\phi},$$

where n and n' are the ordinary and extraordinary indices, and e the thickness of the quartz plate. J. J. S.

1121. *Rotatory Dispersion of Quartz.* **E. Gumlich.** (Annal. Phys. Chem. 64. 2. pp. 333–359, 1898.)—The rotation produced by quartz-plates was measured for different wave-lengths throughout the visible spectrum, a form of Half-shadow apparatus due to Lummer being used for the measurements. The results were applied to a number of theoretical formulæ given by different writers for the rotation, and that due to Boltzman satisfies best the results of the experiments. Considering only the visible spectrum, three terms of the series suffice; but if the results of other investigators on the infra-red and ultra-violet are included, then five terms are required. The formula then is

$$\phi = \frac{7{\cdot}08114}{10^6 . \lambda^2} + \frac{0{\cdot}173321}{10^{12} . \lambda^4} - \frac{0{\cdot}0056761}{10^{18} . \lambda^6} + \frac{0{\cdot}00042255}{10^{24} . \lambda^8} - \frac{0{\cdot}0000075338}{10^{30} . \lambda^{10}},$$

where ϕ is the specific rotation and λ the wave-length in millims.

The temperature-coefficient is found to be independent of the wave-length between the limits $\lambda = 656\,\mu\mu$ and $\lambda = 436\,\mu\mu$. For the interval 0° to 100° C. the formula is

$$\phi_t = \phi_0[1 + 0{\cdot}000131t + 0{\cdot}0_6195t^2],$$

and at about 20° for small differences the linear formula

$$\phi_{20} = \phi_t[1 + 0{\cdot}0_314(20° - t°)]$$

suffices. J. B. H.

1122. *Radiation from Rock-salt.* **M. Abramczyk.** (Annal. Phys. Chem. 64. 4. pp. 625–654, 1898.)—The objects of this investigation were to discover :—(1) Is the radiant heat emitted by rock-salt monochromatic ? (2) If not monochromatic, how far can impurities in the rock-salt explain that monochromatism which has been observed ? (3) Does the coefficient of absorption approach a very high value for diminishing temperature-difference between absorbent and radiator, both these being of rock-salt ?

To test the first, the radiation from a heated plate of rock-salt 1 mm. thick was allowed to traverse one of a set of three plates of rock-salt 1, 2, and 3 mm. thick, and the absorption produced by each plate measured. A bolometric method was used for the measurements. The radiating plate was heated to different temperatures, but the absorbing plates were kept at 15° C. The results are best understood from the curves given in the paper; but if the coefficient of absorption is calculated from these it is found to be by no means constant, which it would be were the radiation monochromatic.

To determine the influence on the radiation of the minute globules of water or solution always present in the body of the rock-salt, the capillary space between two plates of rock-salt separated by thin strips of mica was filled with water, and the radiation emitted by the rock-salt and water compared with that emitted by the two plates alone. The presence of the water increased the radiation by about 48 per cent., and on passing it through a rock-salt plate almost none of the increase of radiation was absorbed.

The influences on the radiation of the thickness of the plates, and also the polish of their surfaces have been experimented on. The reflecting-power of rock-salt and the radiation from fused sodium chloride are also considered. J. B. H.

1123. *Residual Rays of Rock-salt and Sylvine.* **H. Rubens** and **E. Aschkinass.** (Annal. Phys. Chem. 65. 2. pp. 241–256, 1898.)—The authors have succeeded in isolating and examining in detail the extremely long heat-rays obtained by several successive reflections at the surface of rock-salt and sylvine. These rays are considerably beyond those obtained from quartz, mica, and fluor-spar by a similar process. The measurement of their wave-length was rendered possible by the substitution of a sensitive thermopile for the bolometer. The thermocouple consists of 20 iron-constantan couples, whose odd junctions are arranged in a vertical line. The wave-lengths are determined by means of a grating consisting of silver wires 0·1858 mm. thick, with a grating constant of 0·3716 mm. The rays are derived from an Auer burner, and reach the thermopile after five successive reflections at the prepared surfaces of the salts. The result obtained for the wave-

length of the residual rays of rock-salt is 51·4, and of sylvine 61·1. These wave-lengths are the longest hitherto obtained by optical means, and are 70 times smaller than the shortest waves hitherto attained on the electromagnetic side. In their properties they have indeed a closer resemblance to electromagnetic waves than to light waves. The rays in question are strongly absorbed by fluorspar, glass, calcspar, and hornsilver. Among liquids, water, alcohol, and ether absorb them entirely; carbon bisulphide, benzol, and petroleum transmit them; and olive oil transmits a large proportion of the sylvine rays while absorbing the rock-salt rays. Most of the bodies which transmit these rays belong to that class for which the dielectric constant is equal to the square of the refractive index for infinitely long waves. Such bodies have no absorption-bands in the infra-red spectrum. E. E. F.

1124. *Magnetic Rotatory Polarisation and Clausius' Axiom.* **M. Brillouin.** (Écl. Électr. 15. pp. 265–269, 1898.)—This is a criticism of a paper by W. Wien (Ann. Phys. Chem. 52. pp. 132–165, 1894), who asserted that by an optical apparatus there described it was possible to transfer radiant heat from the cooler to the hotter of two sources of light, in apparent contradiction of Clausius' axiom. In obtaining this result, reflections at the surfaces of the different media were neglected. Brillouin shows that it is necessary to take account of the whole series of reflections, and that when this is done the result is in accordance with the principle of Clausius. G. B. M.

1125. *Cornu's Theory of the Zeeman Effect.* **O. M. Corbino.** (Roma, R. Accad. Lincei, Atti, 7. pp. 241–246, 1898.)—The author points out the fallacies in certain arguments of Righi's, which would, if correct, make Cornu's interpretation inadmissible. G. B. M.

1126. *Photographic Irradiation.* **Ch. Féry.** (Comptes Rendus, 126. pp. 890–893, 1898.)—This is the spreading of the image of a bright point. The corresponding part of the film acts as a secondary source of light and affects neighbouring portions, until the distance becomes such that by absorption the intensity of illumination falls below the limit at which any chemical change will be induced. This distance increases in arithmetical progression as the quantity of light increases in geometrical progression. Experiments with backed plates confirmed this result, which is independent of reflections from the glass and of the aberrations due to the lens. A. D.

1127. *Rontgen-Ray Tubes.* **H. L. Sayen.** (Frank. Instit. Journ. 145. pp. 441–446, 1898.)—The author describes a tube with an auxiliary tube containing some substance which gives off water-vapour on being heated : heat is applied by internal sparking in this auxiliary tube, adjustable as required so as to keep the vacuum constant at any desired value. A. D.

1128. *Visibility of Röntgen Rays.* **F. de Courmelles.** (Comptes Rendus, 126. pp. 919–921, 1898.)—Out of 240 pupils in the Blind School, nine (five females and four males) were found able to perceive Röntgen and kathode rays as colour, while two (one of each sex) perceived a painful sensation. Of the nine, two females and three males also perceived fluorescence rays from a platinocyanide screen under Röntgen rays. In all these cases the lesions causing blindness were peripherical, not central. A. D.

1129. *Radiography.* **F. Garrigou.** (Comptes Rendus, 126. pp. 1104–1105, 1898.)—If the rays from a focus-tube be restricted by passing them along tubes of glass or metal, the resultant image is clearer and gives more detail with shorter exposures. A. D.

1130. *Transparency to Röntgen Rays.* **F. Re.** (Elettricità, Milan, 17. pp. 261–264, 1898.)—On considering Dölter's scale of relative transparencies (diamond, corundum, talc, quartz, rock-salt, calcspar, cerusite, and realgar) it is seen that the transparency does not diminish with the increase of density or of molecular or atomic weight. Precisely in those cases where it can be said that the relative molecular distances are known, it is found that the transparency increases with the increase of these. In gases of simple molecular structure, the size of the molecules may be neglected in comparison with the molecular distances. Then in two gases the molecular distances are proportional to the cube roots of the respective molecular volumes, *i.e.*, of the molecular weights divided by the corresponding mass-densities. In liquids and solids we cannot neglect the relative size of the molecules in this manner ; but with low densities and simple molecules, doing so may lead us towards some useful conclusions. In gases, the molecular distances being equal, the transparencies are about the same; in solids the differences are much greater. Vapours of thallium chloride, KBr, NaBr, are transparent : the salts in powder are opaque. Liquid bromine is opaque; bromine vapour is very transparent; and so on. In many cases the transparency falls off as the density increases ; but monochloracetic acid is less transparent than trichloracetic (P. C. Frankland), alcohol is twice as transparent as water (O. Zoth). C, H, and O in a molecule tend towards transparency; but the introduction of chlorine, phosphorus, etc., introduces opacity. A high temperature in gases, increasing the

molecular distances, increases the transparency. Cryptochrosis consists in this, that successive layers of a given substance are found to be proportionately more transparent to such Röntgen rays as have traversed the preceding layers. The author finds that it can be explained by assuming that the radiations undergo in each stratum a transformation into rays which are capable of traversing the succeeding strata. A. D.

1131. *Transformations of Röntgen Rays.* **G. Sagnac.** (Écl. Électr. 14. pp. 509–514, 547–555; and Comptes Rendus, 126. pp. 887–890, 1898.) (See Abstracts Nos. 245, 491, 765.)—The secondary rays discharge electric charges as Röntgen rays do. All substances emit secondary rays when struck by Röntgen rays; but like the photographic effect the discharging effect of these rays, when from aluminium, is much less in proportion than their effect on a fluorescent screen. Aluminium interposed in the path of the exciting Röntgen rays diminishes the discharging effect of the secondary rays much less than it does when interposed in the path of the secondary rays. The effect of Röntgen rays in inducing these secondary rays may be much greater than their effect upon the air traversed by the lines of force. The secondary rays render air electrically conductive in the same way as Röntgen rays do, and need not themselves impinge on the charged conductor. When Röntgen rays strike a charged conductor, there are three systems: the incident Röntgen rays, the secondary rays from the metal impinged upon, and secondary rays from the air itself. When secondary rays strike it there are tertiary rays formed, which are still more promptly absorbed by the air, rendering it conductive in a still thinner stratum round the charged conductor. The discharging effect of secondary rays increases with the volume of gas traversed by these rays, passing through a maximum in the case of a plane condenser, but continuously increasing in the case of a closed one. Every particle of a substance impinged on by Röntgen rays gives out secondary rays, subject always to the results of absorption of both kinds of rays. Röntgen rays may then be transformed by transmission through thin films, and secondary rays are transmitted in all directions from the surface of emergence of the Röntgen rays as well as from the surface of incidence. If aluminium be interposed between the source of Röntgen rays and a film of zinc, the secondary rays are much more powerful than if it be placed in the path of the secondary rays from the same film of zinc exposed directly to the Röntgen rays. The order of occurrence of films of different metals thus affects the apparent aggregate transparency to Röntgen rays. The films must be thin to show this. The production of secondary rays seems limited to about 0·5 micron in the case of gold, 1 mm. in that of aluminium. The total energy of the secondary rays is generally independent of the incidence of the Röntgen rays, and is proportional to the surface impinged upon: the energy received per unit of area, and the depth

(measured along the normal) to which they travel both decrease according to the cosine law, and the actual proportion of the whole energy absorbed is the same in both cases for equal areas. When the obliquity is very great the thickness which must be obliquely traversed becomes too great, and the secondary radiation falls off in intensity.—The secondary rays from different metals differ in their penetrative power; and if any are not absorbed by the medium employed to detect them they produce no effect. Thus rays from aluminium produce very little photographic effect, but have a marked effect on platinocyanide of barium, which is not as good a means for distinguishing between different kinds of secondary rays as the photographic plate or electroscopy. As a rule the secondary rays are much more readily absorbed than the original Röntgen rays, and therefore produce effects disproportionate to their energies. The remainder of the energy absorbed from Röntgen rays, and not emergent in secondary rays, becomes heat (Dorn); and this will enable Röntgen-ray bolometers to be constructed. The secondary rays given out by air differ much less from the original Röntgen rays than do those given out, for example, by zinc. On the whole the phenomena are analogous to those of luminescence rather than of dispersion, and it may be that if Röntgen rays are of small wave-length, the wave-lengths are increased at each transformation. It appears that some of the transformed radiations (*e. g.*, those from zinc) dissipate negative charges a little more rapidly than positive, thereby approximating to the character of ultra-violet light, which dissipates negative charges only, as against Röntgen rays which dissipate positive and negative charges equally. Again, air is very opaque to ultra-violet radiation, and further photographic experiments should be made *in vacuo*. On the other hand, it may be that the Röntgen rays consist of small independent trains of waves; and in that case the result of composition of direct waves with waves which have been hampered, and the train lengthened, by obstacles would be equivalent to direct trains of waves of greater wave-length.—The process of transformation described is clearly not one of mere selection. A. D.

1132. *Transformations of Röntgen Rays.* **D. Hurmuzescu.** (Écl. Électr. 15. pp. 166–168, 1898.)—Results similar to those of Sagnac, extended to explain the fogging of plates by the harder short-exposure tubes now in use, and also the effects attributed to the so-called dark light. Röntgen rays facilitate discharge of a charged body in liquid and solid dielectrics as well as in gases: conclusion, that the discharge cannot be convective but must be conductive. A. D.

1133. *Polarisation of Röntgen Rays.* **L. Graetz.** (Annal. Phys. Chem. 65. 2. pp. 453–457, 1898.)—The author endeavoured to obtain X-rays ready polarised by letting the kathode rays impinge upon crystals. According to Sohncke all fluorescent

crystals send out polarised light. The author used calcspar, tourmaline, andalusite, and dichroite. Now, if the X-rays proceeding from these crystals were polarised, a single tourmaline crystal outside could be used as analyser. The tourmaline tongs would be even more effective. Positive results appear to be obtained on the screen; but photographs showed no trace of polarisation, nor could it be detected with a Nicol. Further observations showed the apparently positive results to be due to inequalities on the fluorescent screen used for observation. It appears, then, that even with this powerful means polarised X-rays cannot be produced. E. E. F.

1134. *Influence of Röntgen Rays on Potential-gradient at Metal Electrodes.* **C. D. Child.** (Annal. Phys. Chem. 65. 1. pp. 152-163, 1898.)—The potential gradient between two metal discs kept at a constant difference of potential was experimentally determined by the author, a water-dropping electrometer being used to explore the region between the plates. This gradient is perfectly uniform under ordinary circumstances, but when Röntgen rays traverse the gap parallel to the plates this is no longer the case. The potential-gradent then becomes greater near the electrodes, and falls off towards the middle of the gap.

The paper contains a number of tables and curves giving the results of experiments made under a large range of conditions. The general conclusions deduced from these experiments are :—

1. The presence of Röntgen rays increases the potential-gradient near the surface of the metal.

2. This potential-gradient diminishes when the Röntgen rays strike the metal.

3. The potential-gradient diminishes most with those metals which absorb Röntgen rays most. J. B. H.

1135. *Becquerel Rays.* **O. M. Stewart.** (Phys. Rev. 6. pp. 239-251, 1898.)—An excellent historical *résumé.* A. D.

HEAT.

1136. *Specific Heat of Anhydrous Liquid Ammonia.* **L. A. Elleau** and **W. D. Ennis.** (Frank. Instit. Journ. 145. pp. 189–198, 280–293, 1898.)—The liquid employed was that commercially supplied by the National Ammonia Co. of St. Louis ; it was tested for purity only by being allowed to evaporate, and then left only a trace of an oily residue due to the process of manufacture and too slight to be taken into account. The mean of nine experiments with a temperature range from 0° to 20° C. gives 1·0206, with a mean error of ±·0077. R. E. B.

1137. *Compressibility and Dilatation of Gases.* **A. Leduc.** (Journ. de Physique, 7. p. 5 & pp. 189–209, 1898.)—Substantially the same subject-matter as that of Abstract No. 300, worked out in more complete detail. A. D.

1138. *Absorbing Power of Lampblack.* **Crova** and **Compan.** (Comptes Rendus, 126. pp. 707–710, 1898.)—The absorbing power of lampblack for radiant energy is generally assumed equal to unity ; in reality it varies within narrow limits with the nature of the black and its mode of application. Various values of the absorbing power have been stated by different authors. In the present paper an account is given of the absorption exercised on a flow of heat from a source at 100°. An absorbing power equal to unity is only theoretically to be obtained by receiving the flux on an orifice, made in an enclosure blackened in the interior, whose surface is negligible compared with that of the enclosure. The ratio of the emissive and absorbing powers being constant, the unit of emissive power is taken as that of an orifice made in a blackened enclosure heated to 100°. The finding of the absorbing power is thus reduced to that of the emissive power. The authors used a stove of copper filled with water at 100°, containing a hollow sphere of thin copper 7 cm. in diameter, blackened inside, and screwed in the interior to one of the sides on which it opens by an orifice of 2·2 cm. The flux which proceeds from an equal surface of the side of the stove adjacent to the orifice and blackened, is compared with that proceeding from the orifice itself. These fluxes were measured by being received on a thermopile connected to a galvanometer. In the result the loss per cent. of the absorption in the case of the copper of the stove was found to be from 0·522 to 0·650. For the same surface covered with black deposited from a candle-flame the loss was 0·068 to 0·1250. For one layer of lampblack washed with alcohol the loss was 0·317 ; for a number of layers (from 1 to 10), each layer being washed with alcohol, the loss regularly diminished to 0·0203.

The authors conclude that :—(1) A layer of lampblack applied in the ordinary way may have losses of absorption attaining to

0·1. (2) Light layers washed successively with alcohol give a resisting deposit and an absorption more and more complete, the loss not falling below 0·02. (3) Platinum-black, smoked and washed with alcohol, permits of arriving at the same limit with a fewer number of layers. J. J. S.

1139. *Conduction of Heat in Gases.* **S. R. v. Smolan.** (Annal. Phys. Chem. 64. 1. pp. 101–130, 1898.)—Experiments on the conduction of heat in rarefied gases are described. The analogy with the coefficient of viscosity is noticed, and the connection of the coefficients of conduction with the mean free path of the gas-molecules, which is deduced from the kinetic theory of gases, is clearly indicated in the results of the experiments. The experimental method adopted is essentially the same as that employed by Kundt and Warburg in their determination of the coefficients of conduction in gases. J. J. S.

1140. *Continuity of Liquid and Solid States.* **A. Heydweiller.** (Annal. Phys. Chem. 64. 4. pp. 725–734, 1898.)—This paper describes experiments undertaken to test the accuracy of experiments by Damien and also by Demerliac, which showed that the elevation of the melting-point of a substance by pressure is not proportional to the pressure, but that a maximum melting-point is reached, after which, according to Damien, increased pressure causes a fall in the melting-point. The author, by employing a capillary-tube method similar to that employed by Cagniard de la Tour for the critical state, has entirely failed to verify the above results, using the same substances as the others and pressures up to 2500 atmospheres.

Although failing at high pressures to show a continuity of the liquid and solid states, the author has succeeded in the case of menthol to show this continuity at temperatures below the melting-point. Liquid menthol when slightly supercooled, if placed in water at about 10° C., solidifies into a perfectly clear transparent solid, but if the water is about 13° C. it solidifies into the usual milky condition. The clear form is not stable, but changes very gradually into the milky one. If a capillary tube filled with liquid menthol have its bottom part immersed in a water-bath at 10° C., then the lower half of the menthol solidifies in the clear form and the solidification creeps slowly up the tube, the surface of separation between solid and liquid becoming gradually fainter until it finally disappears, although there is no difficulty in verifying that the top part of the column is still liquid.

J. B. H.

1141. *Condensation and Critical Phenomena of Mixtures of Two Substances.* **J. P. Kuenen.** (Zeitschr. Phys. Chem. 24. pp. 667–696, 1897.)—A given mixture (characterised by x, the volume-ratio of one of its components) behaves very much like a simple substance, and has isothermals of the same general character with

this difference, that on a pv-diagram they slope upward towards the p-axis during the condensation-stage instead of being parallel to the v-axis. The true critical point R, or point of maximum temperature on the saturation-curve, will thus not coincide with the point M of maximum pressure on this curve, but will correspond to a less pressure and density.

On a pt-diagram the saturation-curves for the limiting values $x=0$ and 1 are the vapour-pressure lines of the pure components which end at their critical points, but for other values of x they form loops which are touched by their envelop in the plait-points P, where the critical phenomena occur that are dependent on the identity of coexisting phases.

These points on a saturation-curve may occur in the order PMR, MPR, or MRP, and it was to realise the last case, if possible, that the experiments in this paper were undertaken. Its peculiarity is that between the temperatures corresponding to P and R isothermal compression of the mixture causes retrograde condensation of the second kind, *i.e.* formation of a *less* dense (vapour) phase which first increases in amount, then decreases, and finally disappears.

Experiments were made with the pairs ethane and nitrous oxide, ethane and acetylene, ethane and carbonic acid, but the individual gases used were not themselves sufficiently pure to allow the expected phenomenon to be observed, though the course of the plait-point curve that was traced showed the possibility of its existence. The fact that one of the mixtures (*e.g.* ethane and nitrous oxide in the volume-ratio 1 : 4) behaves practically as a simple substance, and that for it the pressure at any temperature is a maximum was confirmed and extended up to the critical state; and it further appeared in all cases that addition of a little of either component to the other caused a *lowering* of the critical point, there being thus one mixture for each pair (*e.g.* C_2H_6 and N_2O as 1 : 1, C_2H_6 and CO_2 as 9 : 11) with a minimum critical temperature.

An interesting illustration of the character of the fold is given by drawing isothermals on a vx-diagram, where v represents the volume at either the beginning or end of the condensation: these consist of separate lines stretching from $x=0$ to $x=1$ while the temperature is below the minimum critical point; but above this point they form two branches, one of which begins and ends on the ordinate for $x=0$ and the other on that for $x=1$, one branch disappearing when the temperature reaches the lower of the critical points of the components, and the other when the higher is reached. R. E. B.

1142. *Graphics of the Thermodynamic Function.* **W. Fox.** (Frank. Instit. Journ. 145. pp. 214–227, 1898.)—Some very elementary propositions are here treated graphically by $t\phi$-diagrams; but nothing new is given even in this method, except perhaps the introduction graphically of Rankine's isodiabatic lines. R. E. B.

ELECTRICITY.

1143. *Electromagnetic Induction in Current Sheets.* **G. H. Bryan.** (Phil. Mag. 45. pp. 381–397, 1898.)—The "moving trails of images" so well known in connection with the theory of induced currents in a thin plane sheet are here extended to spherical sheets, and to cylindrical sheets when the inducing system produces a two-dimensional magnetic field. The images start from the source of disturbance and its inverse point and move radially away from the sheet, with velocities varying directly as the distance from the centre, the velocity at the surface of the sheet becoming equal to the velocity of the trails of images in a plane sheet (usually denoted by R). In the case of a cylindrical sheet, when the currents are induced by the generation of a line of poles or a straight current parallel to the axis, the images are of constant intensity equal to that of the source of disturbance. In the case of a spherical sheet, where the source of disturbance is a magnet whose axis points radially, the intensity of the images varies as the $\frac{3}{2}$th power of the distance from the centre. If the currents are induced in a spherical sheet by the generation of a single pole, the images on the *opposite* side of the sheet (representing the magnetic potential on the *same* side of the sheet as the pole) consist of a single pole and a uniform line distribution of magnetism of opposite sign extending to the centre of the sheet or to infinity, as the case may be, and being identical in character with the image of a source in a sphere in Hydrodynamics.

AUTHOR.

1144. *Calculation of Coefficient of Mutual Induction of a Circle and a Coaxial Helix, and of the Electromagnetic Force between a Helical Current and a Uniform Coaxial Circular Cylindrical Current Sheet.* **J. V. Jones.** (Roy. Soc. Proc. 63. pp. 192–205, 1898.) —This paper does not admit of a short abstract. W. R. C.

1145. *Deformations of Dielectric in Electric Field.* **P. Sacerdote.** (Comptes Rendus, 126. pp. 1019–1022, 1898.)—The unitary deformations undergone by a plate of dielectric substance are always proportional, if the temperature be kept constant, to the electric energy per unit of volume, $KH^2/8\pi$. The coefficients are (k_1+a) for the unit deformation perpendicular to the field, (k_2-a-2b) for that parallel to the field, and $\left(k+\frac{c}{3}\right)$ for the variation of volume per unit of volume; a and b being the coefficients of longitudinal expansion and transverse contraction, and c that of cubical compressibility, k_1 the coefficient of variation of K with traction perpendicular to the lines of force, k_2 that with traction parallel to them, and k that with uniform superficial

traction. These k's are all small: if negligible, the result is that there is always contraction in the direction of the lines of force, lengthening transversely, and an increase of volume. A. D.

1146. *Dark Cross in Electromagnetic Radiation.* **J. C. Bose.** (Elect. Rev. 42. pp. 781–782, 1898.)—By interposing between polariser and analyser an artificial structure such as a disc made up by rolling a Morse strip of paper, or a disc of dried wood (transverse section), or a cylinder of cast ebonite rapidly chilled, the dark cross, as projected in space, can be mapped out by a detector. A. D.

1147. *Discharge in Rarefied Gases.* **W. Wien.** (Annal. Phys. Chem. 65. 2. pp. 440–452, 1898.)—Using Lenard's arrangement, the author proves that even in extreme vacua no limit is set to the capacity possessed by kathode rays of producing a negative charge in bodies upon which they impinge. Kathode rays are not deprived of this power by having to traverse a metallic window connected to earth. They are deflected even in a purely statical electric field. By compensating the electrostatic deflection by means of a magnetic deflection, the velocity of the particles may be determined. It is about one-third of the velocity of light, and the ratio of the mass of the particle to the charge carried by it is 5×10^{-8}. It may be proved that both the rays proceeding from the kathode and those proceeding from the anode contain negative charges, and similarly, that positive charges are conveyed by both kinds of rays. The conception of Goldstein's canal-rays may be generalised by saying that both electrodes emit charges of their proper signs from their front surfaces, and charges of the opposite sign from their back surfaces when perforated. E. E. F.

1148. *Mutual Influence of Parts of a Kathode.* **E. Wiedemann.** (Annal. Phys. Chem. 63. 1. pp. 246–252, 1897.)—By peculiarly shaping the parts of a kathode, deflections may be obtained in the kathode rays, analogous to those observed by Goldstein. A. D.

1149. *Action of Kathode Rays on Air.* **P. Lenard.** (Annal. Phys. Chem. 63. 1. pp. 253–260, 1897.)—Kathode and Röntgen rays differ in degree, not in their nature. Kathode rays discharge electrified charges, of either sign, at distances beyond those at which they can produce fluorescence (say 30 cm. as compared with 8); but this effect scarcely seemed to be due to kathode rays themselves, and was found to be due to electric conductivity imparted by them to the air, in much greater measure than that imparted by Röntgen rays of equal phosphorescence-producing power. Air acted upon by kathode rays also contains fog-nuclei in great abundance, much greater than that induced by Röntgen rays (Richarz) of equal phosphorescence-producing power.

A. Paulsen, Copenhagen, has a theory of the Aurora Borealis based on kathode rays: he anticipated in 1894 the fog-producing power of these rays, and showed that the auroral rays have this power.

A. D.

1150. *Rotation of Kathode Rays.* **F. Braun.** (Annal. Phys. Chem. 65. 2. pp. 368–371, 1898.)—A thin bundle of kathode rays impinges upon a fluorescent screen at the end of a vacuum-tube. A bar-magnet penetrates into the vacuum-tube through the fluorescent screen. It is protected by a glass tube. The kathode rays form a ring round the bar-magnet. The author asks whether this ring represents the impact of kathode rays which are in a state of rapid rotation round the pole. A stroboscopic examination shows no evidence of rotation. But that is not conclusive, as the rotation may be too rapid. The author therefore inserts a wire in the diaphragm through which the kathode rays pass. The effect of exciting the magnet is simply to displace the shadow of the wire in one sense or the other, according to the sign of the magnetising current. This argues against a rotation. The kathode rays behave as if they were flexible conductors fastened to definite points of the kathode, and tending to assume a minimum length.

E. E. F.

1151. *Magnetic Action on Kathode and Röntgen Rays.* **A. Sandrucci.** (N. Cimento, 4. 7. pp. 112–120, 1898.)—The author gives an account of an exhaustive series of experiments, establishing for all cases the proposition that the kathode rays behave towards the ampere currents of magnets as rectilinear direct currents would do from the antikathode to the kathode. A vacuum-tube becoming worn by long use tends to reassume the characters of a fresh tube when put in a strong magnetic field whose lines of force are more or less athwart the current in the vacuum-tube. In the same sense even the terrestrial magnetic field acts, lengthening the life of the tube when its lines are at right angles to the tube, that is, when the tube is placed east and west. The magnetic action may hinder the discharge and then act in the same sense as if the tube itself were under a slightly lower vacuum.

A. D.

1152. *Kathode Rays in Magnetic Fields.* **A. Broca.** (Comptes Rendus, 126. pp. 736–738, 1898.)—Description of experiments similar to and in contiuuation of those of Birkeland, on kathode rays in fields of varying intensity from zero to 15,000 C.G.S. The author concludes that there are two kinds of kathode rays,—those of the first sort which roll themselves round the lines of force of the magnetic field, and those of the second sort which follow these lines of force. One of these sorts arises suddenly for a certain value of the field and the rays commence by rolling themselves round the line of force, following a helix traced on a cylinder very slender and with very long step.

J. J. S.

1153. *Multiple Resonance.* **L. Décombe.** (Comptes Rendus, 126. pp. 1027–1028, 1898.)—Photographs made with the aid of a rotating mirror and taken direct from a Hertz oscillator instead of from a secondary circuit show the oscillatory character of the discharge, and further that there is only one radiation of determinate period, which depends on the dimensions of the exciter and is the same throughout a spark-discharge. There is therefore no continuous spectrum of radiation ; and multiple resonance can only be explained in the manner proposed by Poincaré (Archives de Genève, t. xxv. p. 609, 1891) and Bjerknes (Wied. Ann. xliv. p. 74 : 1891), as a result of damping of oscillations. A. D.

1154. *Lecher's Apparatus.* **D. Mazzotto.** (N. Cimento, 4. 7. pp. 5–23, 1898.)—Further researches into the primary and secondary waves in Lecher's apparatus are described, from which it appears that the formulæ usually given are only applicable to the primary waves and to limiting cases of the secondary. The secondary waves are continuous with the primary; they are little influenced by the capacity of the condenser; the condenser-capacities have a maximum effect when they are symmetrically placed between the spark and the bridge ; and it appears that they are produced when between the spark and the bridge there is produced one complete wave with a latent node between the condensers. A. D.

1155. *Temperature of Incandescent Lamps.* **P. Janet.** (Comptes Rendus, 126. pp. 734–736, 1898.) — With four 10-candle lamps taking 0·65 ampere, the temperatures, electrically measured, were 1620°, 1610°, 1630°, and 1720° respectively. A. D.

1156. *Alkalimetric Methods in Measuring Spark-Discharges.* **P. Cardani.** (N. Cimento, 4. 7. pp. 105–111, 1898.)—The author uses a solution of 1 part NaCl in 10 water, faintly coloured (the solution being invariably somewhat alkaline for this test) with phenolphthalein, and brought back by means of a few drops of N/200 oxalic-acid solution until the colour is a very pale rose. The electrolytic apparatus is such as to exclude the carbonic acid of the air. On passing spark-discharges the red colour due to caustic soda soon appears. Take this reddened solution and the original pale-rose solution ; discharge the colour of the former with a N/200 solution of oxalic acid ; add just as much N/200 solution of caustic soda as will bring this solution to the same tint as the pale-rose solution. The difference between these two quantities gives the quantity of caustic soda produced by the discharge. Dividing this by the number of sparks we get the quantity of soda liberated at each spark ; and dividing the corresponding sodium by the electrochemical equivalent of sodium, we find the quantity of electricity discharged per spark. The numerical results work out with great exactitude. A. D.

1157. *Thermophones.* **F. Braun.** (Annal. Phys. Chem. 65. 2. pp. 358–360, 1898.)—The periodic changes of length or bulk produced by an oscillating current may be utilised for the electrical propagation of sound. The effect may be indefinitely increased by superimposing a steady current upon the variable current. A bolometer is inserted in the secondary circuit of a small induction-coil. As long as the secondary current alone traverses the bolometer, no sound is heard. But as soon as an independent constant current is made to traverse the bolometer, every impulse of the induced current produces a noise in the bolometer, which in this case acts like a telephone. The loudness increases with the strength of the steady current. On replacing the induction-coil by a microphone, nothing is heard. But even then, the sound may be brought out by Simon's sensitive arc. This is due to the strong steady current traversing the arc. If three or four secondary cells are put in circuit with a bolometer and a microphone, anything spoken into the latter is distinctly reproduced by the microphone. The bolometer may be replaced by strips of thin brass.

E. E. F.

1158. *Luminosity of Immersed Electrodes.* **F. Braun.** (Annal. Phys. Chem. 65. 2, pp. 361–364, 1898.)—Aluminium electrodes in an electrolytic cell charged by an alternating current emit over their whole surface a white or yellowish-red light, which changes into blue as the current becomes stronger. The phenomenon is best studied by means of a thin strip or wire of aluminium. This is viewed in a revolving mirror, together with the phosphorescent patch deflected by a magnet which is used by the author as an alternate-current indicator. The wire commences to glow at a very definite phase of the current which produces a development of hydrogen at the aluminium electrode, and ceases at a very definite phase of the vanishing current. The result is a sharply-defined intermittent patch of light in the rotating mirror, which may be utilised for the discrimination of current phases. Magnesium and zinc in Na_2S solution also show luminous effects, though feebler. E. E. F.

1159. *Determination of the Frequency of Alternating Currents.* **C. Kinsley.** (Phil. Mag. 45. pp. 339–347, 1898.)—The accurate determination of the frequency of alternating currents is often of importance. This has been found readily possible by the use of a telephone and a resonance-tube. It is suggested that the resonance-tube be of hard drawn brass, and that a dry piston be used to vary its length. The note given by the telephone in front of the tube, when operated by an alternating current from any commercial machine, will be a composite one whose fundamental has a periodicity equal to that of the alternator. It was found also that *all* of the harmonics, not merely the odd ones, were present up to a periodicity of at least 1200 per sec. Therefore, in order to determine the frequency of the alternating current it

is merely necessary to get from the resonance-tube the frequencies of two successive harmonics. The greatest common divisor of these frequencies will then be the frequency of the alternating current. By means of tables the determination of frequency, from the length of the resonance-tube, becomes a very simple matter. As an illustration the following case is given:—

Let the diameter of the tube used be 5 cm. Temperature, 20° C.

From Table I.		From Table II.		
Observed length. l.	Correction for diam. = 5 cm. c.	Equivalent length. ρ.	Frequency at 20° C. n.	Frequency at 21° C. n.
18 cm.	2·02	20	426·7	427·4
19 „	2·02	21	406·3	407·1
20 „	2·02	22	387·8	388·5
21 „	2·01	23	370·9	371·6
22 „	2·01	24	355·4	356·0

For one harmonic,

$$l=21{\cdot}68, \quad c=2{\cdot}02, \quad \rho=23{\cdot}70, \quad n=360{\cdot}00;$$

for the next harmonic,

$$l=18{\cdot}30, \quad c=2{\cdot}02, \quad \rho=20{\cdot}32, \quad n=420{\cdot}2.$$

The highest common divisor is 60·0, which therefore gives the frequency of the current: one of the above harmonics was the sixth and the next one the seventh. The method used in computing the table is explained and the constants used are given. The readings can be made more quickly and with less relative error than is found to be possible in many other electrical instruments—such as a Kelvin balance for instance: hence the use of this method for rapid and accurate measurements is quite possible. When it is desirable to get the actual periodicity as well as relative values, the above method can be readily used. It requires no difficult standardisation such as is necessary with the vibrating wire and rod methods. AUTHOR.

1160. *Measurement of Phase-Difference.* **A. G. Rossi.** (Écl. Électr. 15. pp. 353–361, 1898.)—The methods discussed refer to sine-currents only. The theory of two instruments—a split dynamometer and a rotating-field phase-meter—is worked out at length. A combination of these two into a single instrument is described, with some constructional details. A. H.

1161. *Graphic Registration of Phase-Difference.* **A. G. Rossi.** (N. Cimento, 4. 6. pp. 401–407, 1897.)—On the principle that the summation of two waves makes beat-waves, the amplitude of which is a sine function of the time, the author shows how to

draw and interpret curves for the purpose of registering and ascertaining differences of phase between two practically sinusoidal currents. A. D.

1162. *Graphical Methods in Alternate-Current Problems.* **C. E. Guye.** (Écl. Électr. 15. pp. 363–369, 1898.) [See Abstracts Nos. 524 and 796].—The author considers the graphical solution of various problems involving combinations of resistances, inductances (self and mutual), and capacities. The use of *equivalent* resistances, etc., is explained: in the case of problems involving complicated networks of conductors, the introduction of such "equivalent" resistances, inductances, and capacities for a whole group of conductors, frequently results in a considerable simplification of the problem. [*To be continued.*] A. H.

1163. *Conductivity of Liquids in Thin Layers.* **G. B. Bryan.** (Phil. Mag. 45. pp. 253–270, 1898.)—Koller (Wien. Ber. 98. ii. *a.* p. 201, 1889) found that the specific resistance of some liquids, such as alcohol, turpentine, etc., increases as the thickness of the layer between the electrodes diminishes. The author reinvestigates the phenomenon. Measuring the resistance by a direct-current method, aniline gave numbers which varied with its purity, and were also affected by the length of time during which the current had passed, and to some extent by polarisation. The numbers obtained confirmed Koller's result. Using an alternating current, the thickness of the layer of electrolyte (0·175 to 10·17 mm.) has no effect on the specific resistance of aniline after the lapse of some hours, though when the apparatus is first put together the effect is noticed. With distilled water and alcohol the larger specific resistance of thin layers is again found, but is only apparent, the increase of resistance per unit increase of thickness being constant after the first thin layer. The discrepancy is therefore probably due to imperfections in the electrodes and their adjustment, and to polarisation. A more perfect apparatus and more rapidly alternating current being used, the specific resistance is found to be independent of the thickness of the layer of electrolyte. T. E.

1164. *Electrolytic Conductivity of Potassium Permanganate Solution.* **E. Legrand.** (Comptes Rendus, 126. pp. 1025–1027, 1898.)—The molecular conductivity increases with the dilution, and tends towards the limiting value 124 observed by preceding experimenters for neutral salts at 25°. It also increases with rise of temperature, the less rapidly the higher the temperature.

A. D.

1165. *Hysteresis Losses.* **C. Maurain.** (Écl. Électr. 15. pp. 409–414, 1898.)—The method employed to determine the

energy lost in a cycle is a modification of that used by J. and B. Hopkinson. An intermittent contact on the axis of an alternator enables the observer to find the difference of potential between the extremities of an inductionless resistance, R, forming part of the circuit, and between the extremities of the magnetising coil. The first is equal to Ri, i being the strength of the current at the moment considered, and the second is $ri+d\phi/dt$, r being the resistance of the coil, and ϕ the magnetic induction. The value of $d\phi/dt$ can thus be calculated, and a curve constructed, representing its variation in value during a period. An integration of the curves gives the value of the induction at any instant.

The author employs iron in the form of cores. There are five altogether; one is of solid iron with a circular section, and the others are made of iron wires of diameters 2·68, 1·57, 0·5, and 0·2 mm. respectively. He gives two series of curves with fields as abscissæ and inductions as ordinates, the frequencies being respectively 18·36 and 54·01. The curves, in general, show the well-known protective action, increasing with the frequency, of induced currents. With the solid iron they are of an oval shape, and they approach more and more to the curves obtained by what may be called the statical method (Ewing and others) with diminution of the diameter of the iron wire.

The author is inclined to the belief that his curves show a true retardation of the maximum induction behind the maximum current, *i. e.* a retardation which is independent of the currents induced in the core, and which is of the order of magnitude of 1/1000 of a second. He finds that the hysteresis loss in a cycle is practically independent of the frequency. A. Gs.

1166. *Magnetic Screening.* **H. du Bois.** (Annal. Phys. Chem. 65. 1. pp. 1–37, 1898.)—This paper contains Parts 2, 3, and 4 of what is practically a treatise on the subject of magnetic screening. The author has also published it in English in a series of papers in the 'Electrician' (see Abstract No. 954). J. B. H.

1167. *Tangential Magnetic Screening Action.* **H. du Bois.** (Annal. Phys. Chem. 65. 2. pp. 403–407, 1898.)—The case of magnetic screening usually investigated consists in the enfeebling of magnetic lines of force impinging vertically, or nearly so, upon the screening surface. But many electricians have assumed, in addition, the existence of a screening action against lines of force running parallel to the surface of the screening substance, as in the case of a cylinder surrounded by concentric lines of force. The simplest case is that of a hollow toroid of some magnetic substance. Two cases may be distinguished. The first case, that of interior tangential screening, takes place when the magnetising coil lies in circles concentric with the toroid on its outer surface. The second case, that of exterior screening, when the

magnetising current flows through the centre of the generating circle of the toroid. Kirstädter failed to find a trace of the former, whereas the exterior action was alleged to have been observed by W. v. Siemens. The author attributes the alleged screening to a dispersion of the lines of force in the equatorial section of the toroid, and to other sources of error. He believes that tangential screening effects are absent even in hard steel. E. E. F.

1168. *Magnetisation.* **P. Morin.** (Écl. Électr. 15. pp. 154–166, 1898.)—The mean intensity of magnetisation increases very rapidly with the length of the bar (magnetised to saturation), at first more rapidly than the length, then more slowly, and tends to a maximum value. In long magnets of different lengths, the only difference is in the length of the central region of uniform magnetisation : the terminal regions are identically similar. A magnet of about 50 diameters length has no central region of uniform magnetisation ; and each terminal region is then 25 diameters long. The equivalent ideal magnet would be about 30·5 diameters long ; and therefore the free magnetisation is more towards the ends of the uniform central region than towards the extremities of the magnet. In each terminal region the magnetisation increases with increasing rapidity from the extremity towards the midpoint of the magnet ; and it reaches a maximum which is the magnetisation of the central uniform region of the magnet. When the magnets are shorter than twice the length of one such terminal region, the magnetisations starting from the extremities are the same as before, but a corresponding part of each terminal region is cut out. Consequently, since the curves are flattest at the ends of the magnet, the ideal uniform magnet is more nearly attained the shorter the magnet ; and the relative length of the corresponding ideal magnet is greater the shorter the actual magnet. These results are confirmed, with merely numerical differences, by a long series of experiments ; and they are not in disaccord with those of Coulomb and Bouty, which were mostly obtained from magnets long enough to present a central uniform region. Precisely similar results are obtained by building up a magnet out of magnetised steel wires. Therefore, if we consider the magnet as made up of filaments one molecule thick, each such filament would have its terminal region not more than 25 molecules long. Also, since the terminal magnetisation after saturation is independent of the length of a magnet, and depends only on the metal and the area of cross-section, the same would apply to magnetised discs one molecule thick. There will thus in the case of saturation in ordinary space be two maxima, a terminal-face maximum, and a central-portion maximum. Both these maxima will be higher in an exterior magnetic field, but in this case both again reach a superior limit ; and both return to their former value when this is abolished. When a filament is more than two molecules long the intermediate molecules are in the magnetic field of the others,

and four molecules have more than four times the magnetic moment of a single molecule; and so on for greater numbers; and the free magnetisation will go on increasing as we travel from the extremity towards the centre, until a limit is reached which is uniform throughout the central region. In a magnetised disc made up of two parallel molecules the molecules tend to demagnetise one another; an additional molecule tends to be demagnetised by both, and so for greater numbers, a limit being reached with a maximum of intensity at the edges, which maximum is, however, less than that at the extremity of a single magnetic filament. By synthesising such magnetic filaments or discs we arrive, for real magnets, at distributions such as those investigated.
A. D.

1169. *Elongation during Magnetisation.* **G. Klingenberg.** (Journ. de Physique, 7. pp. 287–288, 1898.)—There is a close parallelism between the elongation in a bar of steel or iron and the magnetisation: the curves are similar, both tending towards a maximum; the residual phenomena are similar, but greater in steel; shocks reduce hysteretic and residual phenomena for both elongation and magnetisation. Residual elongation diminishes as the traction increases. A. D.

1170. *Susceptibility of Diamagnetic and Weakly Magnetic Substances.* **A. P. Wills.** (Phil. Mag. 45. pp. 432–447, 1898.)—The author describes a new and very simple method for discovering the coefficients of magnetic susceptibility or permeability; the method being applicable to Solids, Liquids, and Gases; results, however, being given for Solids only.—A very powerful magnetic field is secured by means of a large electromagnet; the prismatic shaped pole-pieces of this magnet are so placed that their plane faces are directly opposite each other and separated by a distance of 1·5 cm. These pole-faces are rectangular in shape, and of dimensions 8 cm. by 1·5 cm., the long edges being horizontal. Between these pole-faces is obtained a practically uniform field of great strength. Slabs are prepared of the substance for which the coefficients are required. These have approximately the dimensions 8 cm. by 4·5 cm. by ·5 cm.

In making an experiment a slab is suspended by means of a long wire from one end of the beam of a very sensitive balance in such a way that the long edges of the slab are vertical, the medium edges parallel to the long edges of the pole-faces, and the short edges perpendicular to the same. The bottom surface of the slab is made to lie in the horizontal plane of symmetry of the two pole-pieces, and the slab is in every other way symmetrically placed in respect to them. Thus the bottom surface is in a very strong magnetic field, while the top surface of the slab is in a comparatively weak field. So placed, the substance experiences a mechanical force in the vertical direction only; for by symmetry the mechanical

forces in the other directions annihilate each other. The total mechanical force in the vertical direction and measured by the balance is given by

$$P = \frac{\kappa A}{2g}(H^2 - H'^2),$$

where P is the force, κ the required coefficient, A the area of the horizontal section of the slab, H the magnetic force at the bottom surface of the slab, H' that at the top surface, and g is the known acceleration due to gravity. Experiment shows H'^2 in comparison with H^2 to be negligible. We have then for κ:

$$\kappa = \frac{2gP}{AH^2}.$$

H is found by measuring the force of the field upon a conductor in it carrying a known current. The same balance mentioned above is used for this purpose.

The coefficients for many substances are given in the original paper. The values of $\kappa \times 10^6$ for bismuth, glass, marble, wax, and shellac were found respectively to be $-12{\cdot}55$, $-{\cdot}578$, $-{\cdot}832$, $-{\cdot}560$, and $-{\cdot}394$.

Experiments upon bismuth and wax showed that within wide limits the strength of the field used had no effect as regards a change in the value of κ. AUTHOR.

1171. *Effect of Soft Iron on High Frequency Currents.* **H. Pellat.** (Comptes Rendus, 126. pp. 731–733, 1898.)—An oscillatory current of high frequency is obtained in a coil B by the ordinary method, on joining the extremities of the wire to the outer coatings of two small Leyden jars, whose inside coatings communicate with the poles of a Ruhmkorff coil. The knobs of these jars are sufficiently close together for a spark to pass between them at each oscillation of the contact-breaker. When the frequency of the oscillatory current (obtained from the knowledge of the capacities and of the coefficient of self-induction of B) is 300,000, if a second coil B' with a layer of fine wire is introduced into the axis of the coil B, sparks of 6 mm. to 7 mm. are obtained between the extremities of the wire of this coil. This is Tesla's arrangement. If then the coil B' is put outside the coil B so that the axes coincide, the E.M.F. of induction is too small to produce a spark between the extremities of the wire of B'. On placing in the interior of the two coils a bundle of wires of soft iron (0·25 mm. diam.), the spark is no more produced.

This negative experiment might appear to show that iron is not magnetised in a magnetic field alternating with high frequency; but another experiment proves that iron is magnetised in these conditions, and that its magnetisation may have a considerable influence on certain phenomena.

The coil B' being taken away, the extremities of the wire of the coil B still joined to the outside coatings of the Leyden jar are

put in relation with the two plates of a very sensitive balance-electrometer, the displacement of the movable plate being observed by means of a microscope with cross-wires. When the apparatus is in action, the movable plate is displaced under the influence of an electric force proportional to the mean square U of the difference of potential between the extremities of the coil B

$$(U=\int_0^1 V^2 dt).$$

But the author has shown that the introduction into the coil B of a bundle of wire, similar to that used in the above experiment, diminishes considerably the value of U. This effect is not due to Foucault currents, for copper wires or masses of brass produce only an insignificant diminution of U. The same result has been obtained with three different coils. In one case in which the number of periods was 298,000, the value of U, although very small, corresponded to a displacement of the plate of which the $\frac{1}{50}$ part could be appreciated; bundle of soft iron reduced the value of U in the ratio of 3 to 1. The introduction of the iron causes a marked change in the noise of the sparks passing between the knobs of the Leyden jars.

These experiments show that the presence of even a small quantity of iron in the axis of a coil prohibits the use of the classical formula

$$\frac{d(Li)}{dt}+Ri+V=0 \quad \left(\text{with } i=C\frac{dV}{dt}\right),$$

for obtaining the value i by the oscillating current, considering the self-induction L as constant.

This formula leads in fact, for the value of the mean square of the potential difference U, in the case of L constant, to the expression

$$U=n\frac{V_0^2 L}{2R},$$

in which n is the number of interruptions per sec., V_0 the P.D. between the knobs of the Leydens when the spark is going to pass, and R the resistance of the coil B. But L considered as a constant increases by the presence of the iron in the coil, which ought, according to the formula above, to increase U, whilst experiment indicates a considerable diminution. This phenomenon must be considered as due to hysteresis, of which the above relation takes no account if L is considered constant: the flux of induction due to the iron has a retardation of phase on that due to the current alone, and a part of the energy of this current is transformed into heat-energy in the soft iron. J. J. S.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

1172. *Atomic Weights.* **D. Berthelot.** (Comptes Rendus, 126. pp. 954, 1030–1033, & 1415–1418, 1898.)—The molecular weight of a gas is proportional to its limiting density, under an infinitely small pressure. The limiting density is equal to the product of its normal density at 0° C. and atm. pr. into $(1-\epsilon)$, where ϵ is the departure of the compressibility of the gas from Boyle's law, between 0 atm. and 1 atm. at 0° C.; that is, according to Regnault,

$$\epsilon = 1 - \frac{p_0 v_0}{pv} = A_p^{p_0}(p_0 - p),$$

where p_0, v_0 are the normal pressure and the corresponding volume, p, v the observed pressure and volume, and A the mean compressibility between p and p_0. If $p=0$, the expression becomes $\epsilon = A_0^1$, and the molecular weight is proportional to $(1-A_0^1)d$. It remains therefore to find A_0^1. For permanent gases we may justly assume this to be the same between 0 atm. and 1 atm. as it is between 1 atm. and 2 atm.; for liquefiable gases, more calculation is necessary.

From the observed densities and compressibilities ensue the following:—

	H.	N.	CO.	O.
Molecular volume at 0° and atm. pr.	1·00046	0·99962	0·99954	0·99924
Molecular weight	2·01472	28·0132	28·0068	32
Atomic weights (O=16)	1·0074	14·007	[C=12·007]	16

The molecular volume of hydrogen is greater than that of a perfect gas, hydrogen being less compressible at 0° C. than Boyle's law would indicate. The maximum error in the atomic weights is $\pm\frac{1}{5000}$ of their values. The chemical results run for oxygen from 15·866 to 15·897 (H=1), and the value 15·880 is now accepted. M. Leduc's very exact working gives 15·881, or for O=16, H=1·0075. Syntheses of CO_2 from diamond or graphite give C=11·998 Dumas and Stas, 12·009 Erdmann and Marchand, 12·004 Stas (CO_2 from CO), 12·003 Roscoe, 12·011 Friedel, 12·001 to 12·005 Van der Plaats. The chemical methods for nitrogen are roundabout and unsatisfactory: Stas 14·044; Thomsen's data, 14·019; Hill's data (Amer. Chem. Journ. 1896), 14·012. M. Leduc, from the relative densities of CO and N in corresponding states, finds 14·005.

For liquefiable gases, the following are the results of the data of

Leduc, Amagat, and Sacerdote and Mathias' table in the *Annuaire du Bureau des Longitudes* :—

	O.	CO_2.	N_2O.	HCl.	C_2H_2.	PH_3.	SO_2.
Normal densities (O=1) ...	1	1·38324	1·38450	1·14836	0·81938	1·07172	2·04835
Compressibilities between 1 atm. and 2 atms.	0·000760	0·006916	0·007828	0·008132	0·008664	0·009707	0·025992
Critical temperatures	−118° C.	31°·35	36°	52°	37°	52°·8	156°
Constant a in Van der Waals' formula........	0·001588	0·009131	0·010244	0·010442	0·011278	0·012359	0·028544
Constant β in Van der Waals formula............	0·000828	0·002427	0·002682	0·002599	0·002943	0·003069	0·005384
Mean compressibility between 0 and 1 atm.	0·00076	0·00674	0·00761	0·00790	0·00840	0·00937	0·02368
Molecular volume at 0° C. and atm. pr................	0·99924	0·99326	0·99239	0·99210	0·99160	0·99063	0·97632
Molecular weight (O=32)	32	44·000	44·000	36·486	26·020	34·001	64·046

From these values it will be afterwards shown that the atomic weights of carbon, nitrogen, chlorine, phosphorus, and sulphur can be determined as precisely as, and in some cases more precisely than, by chemical methods. A. D.

1173. *Photo-electric Relations of Coloured Salts.* **J. Elster** and **H. Geitel.** (Annal. Phys. Chem. 62. 4. pp. 599–602, 1897.)—Just as chloride of sodium and other salts which have become coloured through exposure to kathode rays have their colour discharged by exposure to sunlight or daylight, so do these salts when they have acquired similar colours through exposure to potassium or sodium vapour. When coloured with a trace of Prussian blue they do not. Everything points towards these coloured products being solutions of traces of the metal in the solid salts. A. D.

1174. *Lecture Experiments.* **Küster.** (Zeitschr. Elektrochem. 4. pp. 503–505, 1898.)—Some lecture experiments are given illustrating the connection between the electrochemical theory of potential difference and certain facts of analytical chemistry. (See Phys. Soc. Abstracts, Nos. 104 & 217, 1897.) B. B. T.

1175. *Relations between Luminous and Chemical Energy.* **Berthelot.** (Comptes Rendus, 127. pp. 143–160, 1898. See also Comptes Rendus, 127. p. 84.)—This series of experiments were conducted at the ordinary temperature under (1) direct sunlight, (2) diffused daylight, (3) darkness; also with interposition of various liquids and solutions; with a duration of weeks or months.—*Nitric acid* and nitric anhydride, when pure, underwent no decomposition in the dark. But the former, under protracted exposure to solar light, gave amounts of oxygen

corresponding to from 12 to 42 per cent. of the total transformation $2HNO_3 = 2NO_2 + O + H_2O$, free nitrogen and nitrous oxide being absent. The effects of light are parallel to those of heat, but produced at a lower temperature. Diluted nitric acid (1·365 sp. gr.) was found to be practically stable in solar light, probably because the layers of NO_2 which might be formed tended to absorb the actinic rays. A solution of potassium dichromate completely arrested the effective solar radiation, whereas ammonio-sulphate of copper in fairly thick layers did not.

Numerous trials were made with chloride of silver, hydriodic acid, and other bodies affected by light, which showed that the changes, as in the case of heat, were reversible under exothermic or endothermic conditions. Copious details of the experiments are given in the original paper. S. R.

1176. *Heat evolved on Wetting Powders.* **T. Martini.** (Rivista Scientifica, 30. pp. 131–132, 1898.)—Anhydrous silicic acid rises 29° C. with water, 32° with ethyl-alcohol. The production of heat is proportional to the quantity of powder used. (Meissner denied this.) A. D.

1177. *Heat of Solution, Solubility, and Freezing-point.* **A. Dahms.** (Annal. Phys. Chem. 64. 3. pp. 507–518, 1898.)—This paper contains an attempt at finding the relation between lowering of freezing-point and concentration for solutions not dilute, in two cases of complete heterogeneous equilibrium, *i. e.* equilibrium between a solution of a non-volatile salt, the salt itself, and the vapour of the solvent, and the equilibrium between two solids and a eutectic mixture of them. Based on a thermodynamic equation quoted from Planck, the author finds that if C_1 C_2 are the concentrations (*i. e.* fractional composition) of the two components of the liquid mixture, θ θ' the absolute temperatures, and r_1 r_2 the latent heats of solution of the two substances (*i. e.* heat absorbed in removing 1 gm.-mol. of each isothermal-isopiestically from an infinite quantity of solution),

$$\frac{d \log C_1}{d\theta} : \frac{d \log C_2}{d\theta'} = r_1 : r_2.$$

The theoretical part is followed by a number of illustrations, in which (i) the heat of separation of NaCl from its saturated solution is calculated from the concentration and the latent heat of water; (ii) the composition of a eutectic mixture of nitrobenzene and ethylene bromide is compared with that found from the latent heats; (iii) it is shown that the formula leads to correct results for the variation in the solubility of naphthalene and ethylene dibromide, diphenylamine in ethylene dibromide, and other cases.

R. A. L.

1178. *Solubility of Iodine in Mixed Liquids.* **L. Bruner.** (Zeitschr. Phys. Chem. 26. pp. 146–151, 1898.)—Determinations are given of the solubility of iodine at the ordinary temperature in mixtures of benzene, chloroform, carbon tetrachloride, carbon bisulphide, ethyl and *n*-propyl alcohols and water. For each pair of liquids, mixtures containing from 0 % to 100 % of the constituents are investigated. Mixtures of a concentrated solution of potassium iodide and water are also used. The quantity of iodine dissolved by a mixture is always smaller than the quantity which the constituents of the mixture would dissolve if separate. The differences are largest in the mixtures containing the alcohols.

T. E.

1179. *Chemical Statics.* **P. Duhem.** (Journ. Phys. Chem. 2. pp. 1–42 & 91–115, 1898.)—This paper is a commentary on and a supplement of Gibbs' memoir. The phase-rule is demonstrated without any assumption that the independently variable components of each of the phases of a system are identical with the independently variable components of the system as a whole. The subjects treated comprise:—(1) The thermodynamic potential of a homogeneous mixture; (2) General theorems of the chemical statics of homogeneous systems; (3) General principles of the chemical statics of heterogeneous systems (α) maintained under a given pressure, (β) at constant volume; and the final conclusion is that every true chemical equilibrium of a system maintained at constant temperature and pressure, or at constant temperature and total volume, is either stable or indifferent. R. E. B.

1180. *Three-Component System.* **H. R. Carveth.** (Journ. Phys. Chem. 2. pp. 209–228, 1898.)—Lithium, sodium, and potassium nitrates were chosen for this system, as (1) they dissolve without decomposition to a homogeneous solution, (2) they form neither solid solutions, mixed crystals, nor double salts, (3) their respective melting-points do not lie far apart: they consequently form the simplest triple system possible. The observations were plotted on a triangular diagram, the points of which we may denote by L, N, K. The isothermals have only a single branch across the K corner for temperatures between 337° and 308°, the fusing-points respectively of KNO_3 and $NaNO_3$; down to 253°, the fusing-point of $LiNO_3$, they have two branches, across the K and N corners respectively; for lower temperatures they have three branches. There is a binary eutectic point on KN for 218°, another on NL for 204°, and a third on NK for 129°: thus, above 218° the branches are all separate, down to 204° two of them only are connected, and below this all three are connected, though they do not form closed curves till 129°. At 119°, the fusing-point of the ternary eutectic, the three branches close into a single point. The points of connection of the several branches lie on lines joining

the ternary eutectic point to the three binary eutectic points which separate the fields in which the several salts occur as solid.

The application to these solutions of the freezing-point method was then considered, but without definite result, possibly because of their great concentrations; and the employment of the triangular diagram in metallurgy, in the examination of alloys, and in other ways was suggested. R. E. B.

1181. *Estimation of Ionisation-Constants by Increase of Solubility.* **R. Löwenherz.** (Zeitschr. Phys. Chem. 25. pp. 385–418, 1898.)—The solubility of an acid is increased on adding a base by the amount of undissociated salt (SB) and the increase of acid ions (dS'). Where the acid is weak the concentration of H' ions will be small, as also that of OH' ions (which may be calculated from the equation $H' \times OH' = K^2$, where K is the ionisation-constant for water, $1{\cdot}14 \times 10^{-7}$ at 25°). Since $H' + S' = B' + OH'$, we have B' nearly equal to S', and the ionisation may be assumed, without serious error, equal to that in a solution of SB (or of LiCl) of the concentration $SB + S'$: this enables SB to be calculated from the increase of solubility, and hence S' and B'. H' is calculated from the equation $k \times SH = S' + H'$, where the product $k \times SH$ is constant and is determined in solution of the acid in pure water. The amount of base unaccounted for exists free as BOH. The ionisation-constant of the base can now be calculated as $B' \times OH'/BOH$. The method applies inversely to acids also.

The method is applied to aniline and *p*-toluidine with cinnamic and *p*-nitrobenzoic acids, giving values agreeing well together and with those of Bredig (Zeitschr. Phys. Chem. 13. p. 321) calculated by his own and by a new method. By choice of acids (or bases) of suitable strength and solubility, constants can be estimated down to 10^{-14}. A number of results are given. B. B. T.

1182. *Inter-relation of Equilibrium Constants in different Solvents.* **B. Kuriloff.** (Zeitschr. Phys. Chem. 25. pp. 419–440, 1898.)—The author tests the equation $K_2 = K_1 k_1/k_2 k_3$, where K_1 and K_2 are the equilibrium-constants of the reaction

$$\beta\text{-Naphthol picrate} \rightleftharpoons \text{Picric acid} + \beta\text{-Naphthol}$$

in benzene and water, and k_1 k_2 and k_3 are the partition-coefficients of the three substances, by determining K_1 K_2 k_2 and k_3, calculating k_1, multiplying by the solubility of β-naphthol picrate in benzene, and comparing with the observed solubility in water. The β-naphthol is estimated by Küster's method with iodine and thiosulphate, according to an empirical table. K_1, determined from the solubility of β-naphthol picrate in benzene on addition of known quantities of one component, varies from 0·63 to 0·84. k_2, allowing for the electrolytic dissociation calculated from Ostwald and Bredig's measurements, is 37 to 42; this is confirmed by

observing the alteration of relative solubility on adding sodium picrate, the degree of dissociation of which is known. k_3 is 63 to 73. The solubility of β-naphthol picrate in benzene is 3030×10^{-6} gram-mols. per litre, whence the solubility in water should be $4{\cdot}7 \times 10^{-6}$. This value is determined, first by the difference of solubility of picric acid on adding excess of the picrate; secondly by the difference in solubility of β-naphthol under the same circumstances; and thirdly by correcting the directly observed solubility of the picrate for dissociation, according to the equilibrium constant determined from the alteration of solubility on adding known quantities of one component. The first method agrees with calculation in showing a very small difference in solubility; the second and third methods give 7·9 and $8{\cdot}9 \times 10^{-6}$. All data are for 29°·5 C. Consideration of the composition of the saturated solutions in benzene and water with varying proportions of picric acid and β-naphthol show that both systems belong to Roozeboom's second type, where two substances form a compound whose melting-point (point at which solid and liquid phases have the same composition) lies between two quadruple points; but if the electrolytic dissociation is not taken into consideration, the aqueous system appears to be of the third type, where the melting-point cannot be reached, owing to previous separation of another solid phase. B. B. T.

1183. *Viscosity of Solutions of Electrolytes.* **H. Euler.** (Zeitschr. Phys. Chem. 25. pp. 536–542, 1898.)—Arrhenius has shown that the viscosity, H, of a solution containing two salts whose concentrations are respectively x and y, may be represented by

$$H = A^x B^y,$$

A and B being viscosity coefficients depending on the nature of the salts. The author assumes that the ions and undissociated molecules in the solution of a single salt may be treated as separate substances, each with its own viscosity coefficient, and writes for the normal solution of a salt

$$H = S^{(1-\alpha)} A^\alpha K^\alpha ;$$

where S, A, and K are the viscosity coefficients of the undissociated molecules, anions, and kathions, and α is the degree of dissociation. Ions of equal mobility influence the viscosity of water to the same extent; it is therefore plausible to assume that they have equal viscosity coefficients. By means of this hypothesis and measurements of the viscosity of solutions of different concentration, the values of A and K for a series of ions are calculated. The connection between the mobilities of the ions (U) and these viscosity coefficients (A) is shown in the following table (for normal solutions at 25°) :—

	U.	A−0·68.	(A−0·68)U.
Li	39·8	0·47	18·7
Na	49·2	0·411	20·2
Mg	58	0·368	21·3
Ag	59	0·379	22·4
Cu	59	0·356	21·0
Ca	62	0·348	21·6
Sr	63	0·337	21·2
Ba	64	0·323	20·7
Cl	70·2	0·282	19·8
NH_4	70·4	0·283	19·9
K	70·6	0·282	19·9
Br	73·0	0·266	19·4
Rb	73·5	0·278	20·4
Cs	73·6	0·269	19·8

The number 0·68 would represent the viscosity coefficient of an infinitely mobile ion. The values for H and OH are quite exceptional, the product (A—0·68)U having the value 126·7 for H and 78·5 for OH.

That some salts diminish the viscosity of water is due to the compression of the water by the attraction between the charges on the ions. This diminution of viscosity may exceed the increase due to the presence of the dissolved ions or molecules.

T. E.

1184. *Separation of Cobalt and Nickel.* **Coehn.** (Zeitschr. Elektrochem. 4. pp. 501–503, 1898.)—From experiments on electrostenolysis the author found that cobalt deposits superoxide at the anode, while nickel does not. This is found to furnish a method of quantitative separation. To prevent deposition at the kathode, a solution of a more easily separable metal (copper) is added. B. B. T.

1185. *Organic Electro-Chemistry.* **M. Krüger.** (Elektrochem. Ztschr. 5. pp. 31–39, 52–58, 72–76, 1898.)—This is a short historical sketch of the results of electrolysing solutions of various groups of organic substances, followed by an account of the action of (nascent) electrolytic oxygen on certain organic substances which are not themselves capable of being broken up into ions.

W. G. M.

GENERAL ELECTRICAL ENGINEERING.

1186. *Earth-Plates.* (Archiv. Post. Tele. 3. pp. 69–75, 1898.) —This paper is a description of experiments commenced in 1892 by the Telegraphen-Ingenieur Bureau on the various forms of earth-plates in common use. A piece of ground of uniform nature was selected, the water-level being 2·60 m. below the surface. The following forms of earth-plates were laid down, both below and above the water-level:—Iron and copper tubes, both bare and tinned, lead tube, copper sheet and copper wire-netting; also iron tube and copper wire-netting embedded in coke. Between 1892 and August 1897, 27 measurements were made of the resistances offered by these earth-plates. Those laid below the water-level showed far less variation in resistance than those above. The smallest resistance was that of the tubes, 3 m. long by 102 mm. diameter, driven in till the upper ends were 4 m. below the ground-level; its value varied between 5 and 11 ohms. The material seems to play no important part, and in no case was any regular change in resistance with time observable. The copper sheets and netting, laid horizontally 3 m. below the surface, had a higher resistance of about 16 ohms. A very great difference was found to exist between earth-plates laid in coke and those in earth. An iron tube laid horizontally 2 mm. below the surface gave 111 ohms as its mean resistance; a similar tube in coke gave 13. Corresponding values for copper netting similarly laid were 51 and 26 ohms. To further test the use of coke for earth-plates, a number of coke masses were laid down, of varying size, but all with their central plane 1 m. below the surface. In these were embedded iron tubes vertically, and copper netting horizontally. Coke in lumps gave better results than in the form of fine ash. Up to a certain point only, the size of the electrodes is of influence; thus copper netting of one-sixteenth of a square metre in area gave 28 ohms, while netting one-quarter of a square metre showed about the same resistance as that one square metre in area, viz. 23 ohms.

Where wet earth cannot be reached the best earth appears to consist of an iron cable laid in a mass of lump coke, the two ends being brought out and connected together. Experiments made in different localities show that the nature of the ground, *i. e.* whether exposed to sun or wind, or in a shady, protected position, has far more influence on the resistance than the nature of the earth-plate. As the earth-plates laid down in 1892 have not yet been taken up, the discussion on the relative durability of the different materials is reserved for a later paper. G. H. Ba.

1187. *Tournaire Electric Call-Indicator.* **L. Montillot.** (Électricien, 15. pp. 308–311, 1898.)—A short account is given

of an indicator devised by C. Tournaire, which contains neither springs nor permanent magnets; the indicator is primarily intended for use with electric bells, but several modifications to suit special cases are described. A. H. A.

1188. *Electric Meters for Differential Rates.* **M. O'Gorman.** (Lightning, 13. p. 486, 1898.)—The price of current is varied daily in a wave proportional to the load-curve by means of a cam whose profile is determined from the station load-curve and plotted in polar coordinates. E. H. C.-H.

1189. *Improved Aron Meter.* (Elekt. Runds. 15. pp. 142–144, 1898.)—This meter comprises a fixed series-coil and a shunt-coil mounted on a vertical axis so that its period of oscillation shall vary as the square root of EC. This pendulum is actuated by a clockwork train, which may be termed the "main" movement. A uniformly running train, termed the "auxiliary" movement, is also employed, together with a counting-train. Since the number of oscillations of the anchor of the main movement varies as $\sqrt{EC}$, it is necessary, in order to read off the watt-hours directly, to employ some mechanical means of quadrature. The following is the theory of the method employed, viz.:—The main movement, in unit time, makes $n=c\sqrt{EC}$ oscillations. Therefore the time of one oscillation $1/n=1/c\sqrt{EC}$. After every m oscillations of the main movement, the auxiliary movement is thrown into action, the periodic time of which is $T=m/n$ or $T=m/c\sqrt{EC}$; the number of cycles or periods in unit time is thus $N=1/T=c\sqrt{EC}/m$. During each cycle the auxiliary movement couples the main movement with the counting-train during a definite time t, smaller than T. In the time t the main movement makes nt oscillations and communicates these to the counting-train, and since there are N cycles in unit time, the advance of the counting-train in unit time $Z=ntN$ oscillations. If now values be inserted for n and N, we have $Z=c^2tEC/m$, wherein $t\ c\ m$ are constants; thus the indications of the counting-train are proportional to EC, *i. e.* it indicates watt-hours.

The main and auxiliary movements are driven from a common mainspring through differential gear, so as to work independently of each other. The main movement consists of an escapement-wheel, an anchor, and a third-wheel. The anchor is provided with a toothed-segment gearing with a bevel-wheel on a vertical arbor carrying the movable coils of the meter so that, as the toothed segment oscillates, the coils turn through a suitable angle in opposite directions alternately, this angle being greater than that through which the anchor moves. The current passes to the movable coils through weak spiral springs. The auxiliary movement consists of a third-wheel, an escapement-wheel, and an

anchor controlled by a small pendulum. On the arbor of the third-wheel of this movement is a wheel having notches in its periphery corresponding in number to the ratio of the number of teeth in the third-wheel to that in the pinion on the arbor of the escapement-wheel; for example, eight. This acts to couple the main movement to the counting-train by means of a pivoted double-armed lever, one arm of which is provided with a pin for engaging with the periphery of the notched-wheel above mentioned, whilst the other arm bears an arbor having two gear-wheels on it. These gear-wheels, when the pin is resting on an unnotched part of the periphery of the notched wheel, engage respectively with a gear-wheel on the arbor of the escapement-wheel of the main movement, and with a gear-wheel forming part of the counting-train. When the pin is in a notch in the notched wheel, the counting-train is disconnected from the main movement. On the escapement-wheel of the auxiliary movement are two pins which only permit a single revolution of the escapement-wheel for each release. The lower pin lies normally against an arm of a pivoted double-armed lever, the second arm of which is acted upon by a pin on the third-wheel of the main movement. When this second arm is actuated by the main movement, the lower pin on the escapement-wheel of the auxiliary movement slides past the first arm and the upper pin comes to rest against it. When the lever moves back again, the second pin is released and the escapement-wheel of the auxiliary movement can rotate freely through one revolution, after which the lower pin again engages with the first arm of the lever. Since the third-wheel of the main movement is provided with four pins, the number N of periods for throwing the auxiliary movement into and out of gear is four times the number of revolutions of the third-wheel of the main movement in unit time, whilst the time that the auxiliary movement is in gear is that of one revolution of the escapement-wheel of the auxiliary movement. The time that the counting-train is in gear is determined by the length of the unnotched parts of the periphery of the disc on the escapement-wheel of the auxiliary movement.

C. K. F.

1190. *Electrical Carbonisation of Filaments.* **L. S. Powell.** (Elect. Rev. 42. pp. 646–648, 1898.)—The author discusses the advantages which may be obtained by carbonising glow-lamp filaments by electricity, and describes some experiments which he has made in this direction. In these experiments brick troughs were constructed on a brick platform covered with a layer of slag-wool. In one experiment the troughs, which were about a metre long, were first provided with a layer of plumbago powder, sprinkled with paraffin, and then packed with carbon blocks on which the cellulose threads were wound, the spaces being filled up with tightly compressed plumbago powder. The current entered and left the troughs by stout terminal plates of carbon. The upper

surface of the troughs was covered by slabs of earthenware, and the whole surrounded by a thick coat of slag-wool. Thec urrent through the troughs at starting was about 18 to 19 amperes, and by gradually cutting out resistance was increased to 30 amperes in 10 hours, and to 65 amperes in 17 hours, at which point it was interrupted. After a lapse of $6\frac{1}{2}$ hours, the current was again started at 27 amperes; in 6 hours' time it again reached 65 amperes, and was then apparently stopped. The majority of the filaments obtained were satisfactory in every respect, their flexibility and "colour" being good, whilst their resistance cold remained practically steady both before and after raising to incandescence in an inert gas. Suggestions are also given as to how the apparatus could be improved. C. K. F.

1191. *Electric Furnaces.* **G. Richard.** (Écl. Électr. 15. pp. 228–233, 1898.)—This is an illustrated description of the electric furnaces of Hughes, Contrado, Regnoli, Siemens and Halske, Horry, Chalmot, Patten, and Strong. W. G. R.

1192. *Switchboard Apparatus.* **J. R. Blaikie.** (Electrician, 41. pp. 209–213, 1898.)—The author endeavours to point out the lack of uniformity among switchboards of existing central stations, and urges the advantages to be gained by combining the best features and standardising switchboards. He appeals to those designing stations to carefully consider the situation and room allowed in the buildings, and also to make the requirements of the supply conform as far as possible to the use of a standard board. He also touches on the subject of establishing a recognised code of engine-room signals from the switchboard.

With these objects in view he criticises the details of switches, instruments, rheostats, etc. commonly in use, and suggests a list of the breaking distances for various pressures and currents, which may be considered as safe under usual circumstances. Criticising boards as a whole, the fire risk is the most largely dealt with, assuming that general convenience and the reliability of each detail is approved. The position of rheostats is then discussed: it is advantageous to place the rheostat on the machine it is intended to govern, but it is also an advantage to use the waste heat from rheostats to keep the board at a higher temperature than the air, thereby avoiding leakage troubles by preventing a deposit of moisture on the surface of the board. The author strongly recommends the prevention of fire by eliminating the cause, rather than the plan adopted by some of abolishing all inflammable material. The use of wood is often convenient for protecting the attendant from "earthed" structures and adds to the appearance of the switchboard. With reference to engine-room signals, several methods are described and criticised. AUTHOR.

DYNAMOS, MOTORS, AND TRANSFORMERS.

1193. *Insulation of Armature Bolts.* **P. Boucherot.** (Ind. Élect. 7. pp. 177–180, 1898.)—The author states that nine out of ten of the French manufacturers of dynamos insulate the bolts traversing the iron laminations of dynamo armatures, while of Swiss constructors only 1 in 10 take this precaution. He then proceeds to discuss the matter in full, after questioning Fischer-Hinnen's conclusion that these bolts never want insulating (see Abstract No. 982). In analysing the distribution of armature flux, the author points out that the currents produced in uninsulated bolts are alternating, and hence that the resistance of these bolts is more than their ohmic resistance. The author's mathematical treatment consists in dividing the instantaneous flux about any one bolt into two parts, one of which passes through the core-plates above the bolt, and the other part below the bolt. He also takes the reluctance in Oersteds of the two paths. He obtains an equation between these two quantities and the current in the bolt. It is obvious that this current tends to increase the density in the armature iron above the bolt. After giving the general equations the author takes examples from practice, and his treatment renders it necessary to obtain the actual distribution by the trial and error method. He concludes that as long as the density in C.G.S. lines per square centimetre in the iron above the bolt does not exceed 10,000 to 12,000, the loss in the bolts is not sufficient to make it worth while to insulate them. In one case, where a density of 19,250 is used, the author works out that the loss would be about 900 watts. He points out, however, that the arrangement of the bolts has much to do with preventing any flux from passing below them. In conclusion he reconciles the divergency in practice between French and Swiss electricians by the fact that in Switzerland, where alternating-current machinery is mostly used, the magnetic induction does not often exceed the limit given; in France, with direct-current machinery, higher inductions have been almost always employed. R. W. W.

1194. *Sayers' Automatic Third-Brush Regulation of Dynamos.* (Electrician, 41. pp. 358–359, 1898.)—If a third brush is arranged to bear on the commntator of a dynamo at a position midway between the ordinary brushes, the voltage between this brush and either of the other brushes will be the same when the machine is running light. When load is put on, the field becomes distorted and the voltage between the backward main brush and the third brush is reduced, while the voltage between the forward main brush and the third brush is increased. If the shunt-coils are wound to give the light-load ampere turns required with half the voltage of the machine, automatic regulation may be obtained by connecting the shunt-coils to the third brush and the forward main brush. Table I.

gives results of a test of a 120-volt 300-ampere machine with the shunt coupled in the ordinary way. Table II. gives the results of a test with the shunt coupled in parallel and one end coupled to the third brush as described; this table shows a rise of pressure on the shunt between no load and full load of 22 per cent.

The arrangement of the third brush can easily be applied to any existing machine having more than one shunt-coil in series, the coils being connected in parallel so as to adapt them for excitation with half the machine voltage.

Table I.

Revs.	Volts at brushes.	Amps.	Revs.	Volts at brushes.	Amps.
698	115·0	58	702	115·0	138
692	114·0	90	686	114·5	155
694	115·0	90	700	114·0	180
698	115·0	110	720	115·0	250
700	115·2	110	730	115·0	250
695	115·0	100			

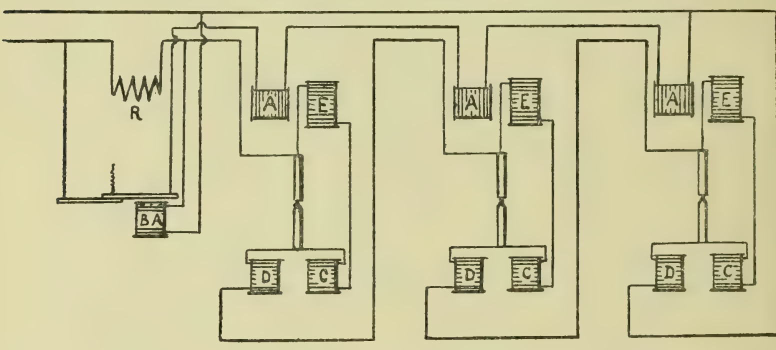
Table II.

Revs.	Volts at main brushes.	Volts on shunt.	Amps.
676	114·0	63·0	0
651	114·5	65·3	50
650	114·5	68·2	90
644	114·0	69·8	139
652	115·0	72·3	174
644	115·0	71·8	171
652	115·0	74·6	234
653	115·0	77·2	280

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1195. *Arc Lamps.* (Elekt. Runds. 15. pp. 107–108, 1898.)—This paper describes a new method of regulating arc lamps in groups of three or more connected in series with each other. This method consists in putting, immediately behind a resistance R arranged in series with and at the supply end of the mains supplying the group, a relay-coil BA in parallel with the mains. This relay BA opens and closes a circuit containing a series of shunt-coils A, A, A acting in conjunction with the feed-mechanism of each of, say, the upper carbon-holders. The feed-mechanism



of each of these carbons is also controlled by an independent coil E arranged in parallel with the arc. In this manner, when the detent controlled by the relay BA and shunt-coil A and that controlled by the independent coil E are both out of engagement, the lamp will feed, but not otherwise. The feeding of each of the lower carbons is similarly controlled by two detents, one actuated by a coil D in series with the arcs (*i. e.* in the main circuit), and the other by a coil C arranged in series with the independent shunt-coil E controlling the upper carbon of each lamp. A special form of lamp is described and illustrated, in which the upper and lower carbons each actuate a separate "fly," the motion of which is controlled by detents as above mentioned. C. K. F.

1196. *Accumulators in Lighting and Traction Systems.* **J. H. Rider.** (Elect. Rev. 43. pp. 136–138 & 176–177, 1898.)—In this paper, which was read before the Municipal Electrical Association, the author describes the various applications of accumulators, showing the methods of connecting the batteries, and discusses the advantages. The energy efficiency of accumulators will seldom exceed 75 % under ordinary conditions, and the prime cost of a battery for a given output of 5 hours' discharge is

given as roughly the same as for steam dynamos and boilers for the same output. The various types of lighting stations are taken in detail, and also the traction station. For the continuous-current lighting station he shows two methods of connecting up the 3-wire system. In the first, most of the dynamos are connected directly to the outer mains only, there being two separate dynamos for balancing the accumulators and the circuits, regulating cells being cut in and out as required. His opinion is, however, that the battery should be charged and discharged as a whole, so as to treat all the cells equally, and this is not possible by the first method. He therefore recommends that all the dynamos should be connected directly across the outers, two smaller ones, in series, having a middle wire-connection as well. There are no regulating-switches at all, except when the battery is being discharged, and then only on special " back E.M.F." cells. There is no necessity to vary the voltage of the dynamos during charging, as the extra voltage is added to that of the bus-bars by means of a small booster in the charging circuit, there being one on each side of the system.

For alternating-current lighting stations the use of accumulators is advocated. They can be used as a stand-by for the exciting plant, and in small stations to maintain the supply during the hours of light load, through the medium of a motor-alternator. He recommends the use of an engine, alternator, and dynamo on the same shaft, with a clutch-coupling between the engine and the two machines. During the daytime the engine would drive both, the dynamo for charging the cells, and the alternator for lighting. When the engine is shut down, the accumulators can drive the dynamo as a motor, and so drive the alternator.

The great advantages of using accumulators in traction-stations are shown by means of a load-curve, where it was found that with this addition one dynamo would easily do the work of two, and could be kept at a very regular load, so regular in fact that lighting could be done at the same time from the same machines. The battery should be connected directly to the bus-bars without any regulating switches; it must be of ample size and with a low internal resistance. To get the best effect, the dynamo should be shunt-wound with a falling characteristic, and a booster should be used during charging. A method of using a compound-wound booster is shown, whereby the battery may either be assisted to charge or discharge, depending upon whether the live current is less or greater than the output of the dynamo. Accumulators are also of great service at the end of long traction-feeders.

He recommends the use of batteries in combined lighting and traction stations, a combination which is of great service to the former. During the evening the machines would be used for lighting, and the accumulators for traction. After midnight the battery would be charged, and through the daytime it would be in parallel with the traction dynamos. The load on engines and boilers could thus be kept nearly constant all the time.

The author complains of the custom of accumulator-makers in not guaranteeing to maintain their cells at greater than about 70 % of their rated capacity, except at heavy rates, and suggests that the original rating is generally too high. AUTHOR.

1197. *Paderno High-Tension Line.* **Semenza.** (Elettricità, Milan, 17. pp. 166–169, 1898.)—There are 6 three-phase lines, the 18 wires being carried by two separate pole-lines, each having 9 wires. By putting all the load on one line, repairs can be carried out on the other, the generators being capable of giving a higher pressure to compensate for the greater drop. The wires on each pole-line are divided into three lines, so as to diminish the self-induction. The existence of three lines, however, tends to produce idle currents in wires of the same phase if any dissymmetry exists in the relative positions of the wires. The most symmetrical disposition, consistent with practice, was found to be the following:—The wires are fixed, 4 on one side and 5 on the other side of the pole, at such distances that any three consecutive wires are at the vertices of an equilateral triangle, the phases being in the order 1, 2, 3, 1, 2, 3, 1, 2, 3, alternately on each side of the pole. The distance between two consecutive wires is 600 mm., and between two wires of the same phase 1039 mm. The wires are of soft copper of 98 % conductivity, and are 9 mm. in diameter [No. 00 S.W.G.]. With spans of 60 metres the sag varies from 0·60 m. in winter to 1·20 m. in summer. The drop of volts due to the resistance and self-induction of the line and transformers is 12·5 %. The loss of energy with a power-factor of 80 % is 9 %. The poles are iron lattice masts, each weighing 400 kilos (880 lbs.) and have concrete foundations. At angles the two poles are connected together by diagonal cross-pieces. Two types of lightning-arresters are employed, the Würtz type, manufactured by the Westinghouse Co., and the Siemens and Halske arrester, consisting of two diverging copper wires supported on insulators. G. H. BA.

1198. *Electric Traction.* **R. C. Quin.** (Elect. Rev. 42. pp. 896–898, 1898.)—In this paper, which was read before the Municipal Electrical Association, the author deals with details of construction and working. He considers that tramway tracks are in general too lightly constructed, and recommends the method of road-construction adopted at Hamburg. In the matter of generators he has a distinct leaning towards high-speed engines without fly-wheels. He does not see the utility of fly-wheels or of uniform motion of the generators, and does not deem the latter essential to secure uniform motion of the tram-car. He defines uniform motion as motion free from perceptible jerkiness. As to gear, he considers worm-gearing efficient but unreliable, and prefers single reduction spur-gearing. He suggests that "ton mile" should be adopted as the unit of efficient working instead of the present "car mile."

On the subject of Overhead construction, he is of opinion that nothing smaller than 000 S.W.G. wire should be used, and that all section-blocks and junctions should be fitted with guard-cheeks. He recommends that the head of the trolley should be loose from the arm, and that it should be anchored by an insulated cord a short distance down the arm, as the only result of the locking of such trolley-head against the bracket-arm or suspension-wire would be its dropping free from the arm. He is further of the opinion that all guard-wires should be capable of withstanding as great a stress as the trolley line itself, and that they should be efficiently connected to earth.

Regarding systems, he believes that the local conditions necessary for the satisfactory working of the Conduit system are freedom from sand and mud on the roads, good drainage, and a wide slot. He says that the initial cost of a Conduit system varies from 30 % to 200 % in excess of the cost of an Overhead system, and that the up-keep under favourable conditions is 10 % greater than the Overhead. He considers accumulator-cars fitted to run one day's journey with one charge to be quite out of practical consideration, owing to their very heavy weight and high initial cost.

The author then deals with the figures given for the working of the Hanover Tramways on the combined Accumulator and Overhead systems; and declares that in his opinion the extra cost of the accumulator cars per mile should have been 2*d*., instead of ·2*d* as given by Mr. Epstein in his recent Institution paper. As bearing out this opinion, he quotes the figures which he obtained from the Hanover Station records as to the energy required per mile by the different types of cars. On the Accumulator system it was 1·5 units, on the combined Accumulator and Overhead cars 1·37 units, and on the Overhead cars ·68 unit. On this basis he arrives at a total cost of 2·12*d*. per car mile for accumulator car over and above that of similar cars worked on the Overhead system.

The author concludes his paper by saying that in the present state of Electric Traction Engineering there is but one good, reliable, and cheap system, viz., the Overhead; that where a combination is necessary, and conditions favourable, Overhead and Conduit come next in order of merit; and that, as at present constructed, Accumulators are not, from a commercial point of view, a satisfactory solution of the traction problem. AUTHOR.

1199. *Electric Traction on Railways.* **P. Lanino.** (Elettricità, Milan, 17. pp. 164–165 & 183–185, 1898.)—Improvements in train service take the form of greater speed and more commodious carriages, the latter necessitating greater weight. Both of these require a more powerful locomotive; but, as the permanent way limits the size and weight of the locomotive, improvement ultimately consists in reduction of weight of the motor per H.P.

The author considers that for steam-locomotives the limit has now been reached, the best types developing 1800 H.P. and weighing 154 lbs. per H.P. For progress, therefore, he looks to

the electric motor fed from a central station, this being the lightest motor known; he believes that the weight can be reduced to 22 lbs. per H.P., and that the absence of any reciprocating parts removes all limit to the ultimate speed attainable.

He describes the scheme of Davis and Williamson for an electric railway between New York and Philadelphia, to run at a speed of 187 miles per hour, and of Behr for a permanent way consisting of 5 rails supported on inverted V trestles. The latter, when tried at the Brussels Exhibition of last year, failed on account of the instability of the trestles.

Criticising the Heilmann locomotive, the author expresses his opinion that this will never prove superior to the ordinary steam one, as the great disadvantage of extra weight (220 lbs. per H.P.) will outweigh the advantages of independent driving of each axle, triple expansion engines and greater regularity in the workiug of the engines. He believes that the present field of electric traction is that of local lines requiring frequent journeys and light trains, and cites as a successful example a three-mile trolley line opened at Baltimore in 1895. The locomotives weigh 90 tons, and have motors of a total power of 1600 H.P. distributed on six independent driving axles. The works' costs per ton mile, when 1, 2, or 3 locomotives are running, are, respectively, 0·186, 0·123, and 0·1015 pence. G. H. Ba.

1200. *Efficiency of Incandescent Lamps.* **J. E. Randall.** (Mech. Eng. 1. pp. 636–638, 1898.)—The author briefly reviews the various advances made in lamp manufacture within recent years, and in illustration of the superiority of the modern cellulose filament over the older bamboo one gives the following table.

Duration of run, in hours.		0	100	200	300	400	500	600	700
Average candle-power.	110-volt Cellulose.	16	15·8	15·86	15·68	15·41	15·17	14·96	14·74
	110-volt untreated Bamboo.	16	14·1	12·9	11·8	11·0	10·4	9·9	9·6
	50-volt treated Bamboo.	16	15·8	15·3	15·0	14·6	14·2	14·0	13·7
Average watts per candle.	110-volt Cellulose.	3·16	3·26	3·13	3·37	3·53	3·51	3·54	3·74
	110-volt untreated Bamboo.	3·20	3·50	3·80	4·08	4·32	4·53	4·75	4·90
	50-volt treated Bamboo.	3·20	3·28	3·37	3·45	3·53	3·61	3·67	3·76

A. H.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

NOVEMBER 1898.

GENERAL PHYSICS.

1201. *Conservation of Energy.* **J. R. Schütz.** (Göttingen Nachrichten, 2. pp. 110–123, 1897.)—The "absolute" conservation of energy for a single particle is expressed analytically by the equation

$$[X(u+\alpha)+Y(v+\beta)+Z(w+\gamma)]dt = d\frac{m}{2}[(u+\alpha)^2+(v+\beta)^2+(w+\gamma)^2].$$

Here u, v, w are the component velocities of the particle relative to a "physical" space, which physical space is itself moving with uniform component velocities α, β, γ; m is the mass of the particle, X, Y, Z the components of force.

The object of the paper is to show that from the principle of the conservation of energy so expressed, having regard to α, β, γ, Newton's three laws can be deduced.

As a simple example he supposes a central collision of two perfectly elastic spheres whose masses are m_1 and m_2, w_1 and w_2 their velocities in the line of centres before collision, ω_1 and ω_2 after collision. Then we suppose an observer to know the law of conservation of energy relative to the physical space in which the spheres are, but to know nothing whatever else. Then he knows that

$$\frac{m_1}{2}w_1^2 + \frac{m_2}{2}w_2^2 = \frac{m_1}{2}\omega_1^2 + \frac{m_2}{2}\omega_2^2,$$

which does not suffice to determine ω_1 and ω_2. But if he be now informed of the complete or "absolute" expression for the conservation of energy in this case, namely

$$\frac{m_1}{2}(w_1+\alpha)^2 + \frac{m_2}{2}(w_2+\alpha)^2 = \frac{m_1}{2}(\omega_1+\alpha)^2 + \frac{m_2}{2}(\omega_2+\alpha)^2$$

for all values of α, he can determine ω_1 and ω_2. That is, in effect, the motion can be determined as it would be from Newton's laws; or Newton's laws can be deduced from the conservation of energy.

S. H. B.

1202. *Translational Motion of the Ether.* **W. Wien.** (Annal. Phys. Chem. 65. 3. i–xviii, 1898.)—The author gives a general survey of the state of the question regarding the non-rotational and non-vibrational motion of the ether. The tendency to connect the properties of the ether with those of ponderable matter has led to the assumption that the ether is capable of motions similar to those of a fluid. The author shows that if the ether has zero inertia and zero compressibility, the motion of electric quantities need not imply the motion of the ether. But such motion takes place when the ether has a finite density, and also when plane electromagnetic waves are reflected by moving insulators. The latter case might possibly be experimentally investigated. The assumption of a stationary ether, though useful for optical theory, offers only an extremely vague mental image. Lorentz has, indeed, shown that a vast number of phenomena may be satisfactorily explained on the assumption of a stationary ether, but that assumption is open to an elementary objection. If a body in the shape of a thin plate is freely immersed in the ether, and its two faces have different radiating powers for heat, the pressure due, by Maxwell's theory, to the radiation would be different on the two faces, and the body would put its own centre of gravity in motion without creating an equal and opposite momentum. It is possible that the ether is only carried along by large bodies, such as the earth, owing to some gravitational effect. It would be well to repeat the experiments of Mascart on the influence of the earth's motion on the rotation of the plane of polarisation in quartz, and those of Röntgen on the magnetic forces excited by moving electric charges, which had negative results. E. E. F.

1203. *New Sprengel Mercury Pump.* **E. Müller.** (Annal. Phys. Chem. 65. 2. pp. 476–478, 1898.)—This is a semi-automatic pump, independent of water-power or an auxiliary pump. It requires only about 3 kgr. of mercury to work it; but one of the reservoirs has to be refilled by hand about every hour. E. E. F.

1204. *Thermo-Electric Measurement of Strains in Iron and Steel.* **Turner.** (Écl. Électr. 15. pp. 416–417, 1898.)—When a metallic wire is stretched it cools, and the cooling can be measured by a thermo-electric junction attached to the wire. When the stress does not exceed five-eighths of the limit of elasticity, it can be exactly measured by the change of temperature. Analogous phenomena are observed in the case of compression. Turner employs a bismuth-antimony junction and a Thomson galvanometer. His first experiments were made on bars of soft and moderately soft steel, of cast iron, and on small columns of steel;

they showed that the galvanometer deflections were proportional to the tensions and compressions. Experiments of greater interest were made on pieces complicated in form, or that presented imperfections of manufacture which can neither be evaluated by theory nor ordinary physical tests. E. C. R.

1205. *Expansion of Tri-metallic Cylinder.* **S. Schwendener.** (Berlin. Akad. Sitzber. 12. pp. 172–175, 1898.)—A circular cylinder is made of longitudinal strips of copper, iron, and zinc; chosen because they possess unequal coefficients of thermal expansion. On heating the cylinder it both bends and *twists.* The author has a theory that certain characteristic growths of certain parts of plants are due to unequal rates of increase. The experiment has a bearing on the theory. A. Gs.

1206. *Richard Planimeter.* (Électricien, 15. pp. 193–196, 1898.) This integrator comprises two parallel discs mounted on a common axis and adapted to be rotated in opposite directions at the same velocity, this being effected by providing their peripheries with teeth engaging with a common independently-mounted pinion, and driving one disc from the axis, the other being free to turn thereon. Between the adjacent perfectly-polished surfaces of these discs is a spheroidal roller of polished steel, fixed on an arbor mounted between centres in a frame which is guided so that the roller shall move along a radius of the rotary discs. On the arbor of the roller is an elongated pinion which gears with a gear-wheel forming part of a counting train, the pinion being of sufficient length to permit the roller to move from the centre to the periphery of the rotary discs without the pinion being thrown out of gear with the gear-wheel. The curve to be integrated is placed on a drum which is adapted to be rotated from the same arbor as that whereby motion is imparted to the rotary discs. Over this drum moves a stylus mounted on the end of an arm, turning about fixed centres and having a toothed segment thereon gearing with a rack on the frame carrying the spheroidal-roller arbor, the parts being so arranged that when the stylus is on the axis of x, the roller will be at the centre of the rotary discs, and therefore the said roller will not be rotated. The number of turns made by the roller is proportional to the area between the curve and the axis of x. There are four dials on the instrument described, indicating respectively units, tens, hundreds, and thousands of square millimetres. C. K. F.

1207. *Laplace's Barometric Formula.* **A. Angot.** (Comptes Rendus, 126. pp. 826–828, 1898.)—A discussion is given of the barometric formula of Laplace. J. J. S.

1208. *Oxygen in Helium Stars.* **F. McClean.** (Roy. Soc. Proc. 62. pp. 417–423, 1898.)—The author has recently returned from the Cape, where he has obtained the spectra of 116 stars

with the aid of his large objective prism attached to the Astrographic Chart telescope at the Observatory there. In his discussion of the spectra he finds in many of the stars what he calls "extra" lines, outstanding from the usual helium and hydrogen lines; and to show the probability of these being due to oxygen, he maps the spectrum of oxygen alongside the stellar spectra. The evidence afforded by the many apparent coincidences seems to him to be sufficient to warrant their being accepted as oxygen lines.

C. P. B.

1209. *Celestial Phenomena and Kathode Rays.* **H. Deslandres.** (Comptes Rendus, 126. pp. 1323–1326, 1898.)—The author, profiting by his observations of the total eclipse of the sun in 1893 to investigate the chromosphere and corona, traces a connection between these phenomena and the appearances exhibited by various combinations of kathode rays. His special experiments with kathode rays have been described in a former paper (Comptes Rendus, 124. pp. 678, 945, 1297, and 125. p. 373). The two points to which he draws special attention are (1) the attraction exerted by an anode on a kathode ray; (2) the non-repulsion by a kathode when a solid body is interposed in the path. In the eclipse of 1893 the author says he found certain regions of the solar surroundings to emit kathode rays. He regards the base of the solar atmosphere as being the seat of this emission, the rays being most intense where the chromosphere is brightest, viz. above the spots and faculæ. By considering the combined result of the solar attraction and the kathode ray repulsion on particles of matter surrounding the sun, he explains the production of the corona and comets. He regards the light of these objects to be produced by the heat and phosphorence induced by the impact of the kathode rays upon the matter surrounding the sun. The fact of the tails of comets being always turned from the sun is also explained. The particles of matter are assumed very small. Then the attraction being proportional to the mass, and the kathode repulsion proportional to the surface, the latter may eventually overcome the former; hence the outward direction of the cometary appendages. Perrin is cited as authority for stating that the kathode ray carries a negative charge, which will modify the electric and magnetic state of the sun, thereby producing such phenomena as auroræ and terrestrial magnetic storms. In conclusion the author points to a possible proof of his view. The varying periods of brightness of comets should correspond to the passage of some large sun-spot or facula near the line joining the comet to the sun's centre.

C. P. B.

LIGHT.

1210. *Electrodynamic Slit Action.* **M. Latrille.** (Annal. Phys. Chem. 65. 2. pp. 408–430, 1898.)—A narrow slit transmits polarised light to a different extent according to the angle between the slit and the plane of polarisation of the light. In electromagnetic waves a similar observation is made. The greatest transmission is obtained when the slit is perpendicular to the direction of the vector of electric force. The author investigates the dependence of the transmitted energy upon the width of the slit. The indicator used is a coherer, and it is found that the direction of the axis of the latter also influences the result, since it reacts more strongly upon electric vibrations along its axis than across it. When the slit is increased in length, the energy transmitted increases rapidly at first, and then more slowly. When the width is increased, the energy transmitted increases slowly at first, and then at a greater rate, up to a certain maximum. The absorption is due to the resonance of the edges of the slit. E. E. F.

1211. *Ketteler-Helmholtz Dispersion Formulæ.* **A. Pflüger.** (Annal. Phys. Chem. 65. 1. pp. 173–213, and pp. 225–228, 1898.) —The formulæ are

$$n^2-\kappa^2-1=\Sigma\frac{D\lambda^2(\lambda^2-\lambda_m^2)}{(\lambda^2-\lambda_m^2)^2+g^2\lambda^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$2n\kappa=\Sigma\frac{Dg\lambda^3}{(\lambda^2-\lambda_m^2)^2+g^2\lambda^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

To test them experimentally, let corresponding values of λ, n, κ be observed: then, by a tentative process, a set of values (λ_m, g) are found so that the graphs for

$$\left.\begin{aligned} y&=\frac{2n\kappa}{\lambda^3} \\ \text{and} \qquad y&=\Sigma\frac{Dg}{(\lambda^2-\lambda_m^2)^2+g^2\lambda^2} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

agree. Now (1) may be written in the approximate form

$$\left(n^2-\kappa^2-a-\frac{b}{\lambda^2}+c\lambda^2\right)\frac{1}{\lambda^2}=\Sigma\frac{D(\lambda^2-\lambda_m^2)}{(\lambda^2-\lambda^2{}_m)^2+g^2\lambda^2}, \quad . \quad . \quad (4)$$

where a, b, c are constants, and the values of (λ_m, g) on the right hand are the same as those calculated from (3). Three separate determinations of n, κ fix the constants a, b, c; and if, for these

values, the equatior (4) is approximately satisfied for a wide range of λ, this is, so far, a confirmation of the original formulæ (1) and (2).

The object of this research is to test the theory by observations upon *solid* substances showing anomalous dispersion, and for this purpose cyanin and fuchsin were selected. To determine κ, the index of absorption, thin films of the pigment were deposited on glass plates, and their thickness found by Wernicke's modification of Wiener's method; κ was then deduced from observations with König's spectral photometer. The values of n (the index of refraction) for fuchsin in the ultra-violet were found by a method suggested by Kayser. An iron spectrum of wide dispersion was obtained by means of a narrow slit and a Rowland concave grating of 6·5 m. focal length. The rays of a portion of this fell upon a double prism of fuchsin deposited on a quartz plate, and after this upon a photographic plate, where two images of each spectral line were produced. Let d' be the distance between them: then, if the double prism is sufficiently far from hephotographic plate,

$$n=\left(\beta+\frac{d'}{\delta}\right)/\beta,$$

where β is the sum of the very small angles of the prism, in seconds, and δ is the (calculated) value of d' for an angular deviation of one second. The values of n for cyanin in the visible part of the spectrum were also carefully determined directly by means of a spectrometer: the results are tabulated and compared with the author's previous results.

The final conclusion is that, so far as the visible spectrum is concerned, the Ketteler-Helmholtz dispersion-formulæ, applied to media whose optical constants are exceedingly variable within a very small range of wave-length, are (allowing for unavoidable experimental errors) so far consistent with observation that they account for the greater part of the two graphs

$$y=\frac{2n\kappa}{\lambda^3}, \quad y=\left(n^2-\kappa^2-a-\frac{b}{\lambda^2}+c\lambda^2\right)\frac{1}{\lambda^2},$$

which are deduced from experiment. There is, however, a discrepancy for the red part of the spectrum.

In the supplementary paper it is remarked that the optical constants of cyanin, deduced indirectly by means of Cauchy's formulæ for metallic reflection [see No. 1212], agree very well with the values observed directly, *except* for the red part of the spectrum. For this the values of n agree with those observed, but the values of κ come out larger. If these larger values of κ are used, the discrepancy above alluded to disappears. G. B. M.

1212. *Optical Constants of Solid Cyanin.* **A. Pflüger.** (Annal. Phys. Chem. 65. 1. pp. 214–224, 1898.)—This is an account of the determination of the optical constants n and κ for solid cyanin by means of Cauchy's formulæ for metallic reflection, and an experimental method already employed by Quincke and Walter. When the results are compared with the author's previous direct determinations [see No. 1211], the values of n are in good agreement throughout; the new values of κ in the red, however, are larger than those found directly. Taking the larger values to be correct, a discrepancy noticed in the author's paper on dispersion disappears. The conclusion arrived at is that Cauchy's formulæ give the values of n and κ with sufficient exactness, and that the best and simplest way of testing the theory of dispersion is by means of experiments on reflection, supposing that superficial lamination can be avoided. G. B. M.

1213. *Refractive Index of Minerals by Total Reflection.* **C. Klein.** (Berlin. Akad. Sitzber. 28. pp. 317–331, 1898.)—The author describes two convenient pieces of apparatus for the determination of the indices of refraction of thin sections; one is made on Kohlrausch's, the other on Abbe-Gapski's principle. There is given a list of liquids, the refractive indices of which lie between pairs of minerals of not greatly different refractive power, and which serve to specify minerals in doubtful cases. A. Gs.

1214. *Change of Wave-Length by Pressure.* **J. Wilsing.** (Ast. Phys. Journ. 7. pp. 317–329, 1898.)—The author wishes to show that the changes in wave-length produced by pressure as determined by Messrs. Humphrey and Mohler [Ast. Phys. Journ. 3. p. 114, 1896; 4. pp. 175, 249, 1896; 6. p. 169, 1897] may be explained as an effect of damping of the vibrations to which the emitted light is due. Increase of pressure always moved the lines towards the *red* end of the spectrum, that is *increased* their wave-length. Also the amount was different for lines of different elements, but in the case of various lines of the same substance, the change was related to the position of the line in the harmonic series expressing the spectrum. Special significance attends the remark that the lines do not become *broadened*, as is the result of simple change of density, as this would show that the shift could not be produced by any *unsymmetrical* broadening of the lines. Attention is drawn to the observations of Kundt, who found that the absorption-bands of substances dissolved in transparent media were displaced also towards the red, the extent depending directly on the dispersion of the transparent medium.

The author gives Lommel's analysis for the case of a damped simple harmonic vibration subject to a periodic impulse, the result of which is to indicate a displacement of the line towards the red when the vibration is damped. Thus far it is in accordance with observation, but the theory goes on to require that the dark

absorption-bands shall suffer the same change, and also that the *breadth* of the line shall vary. Both these latter results are contrary to observation. The author then introduces a modification of Ketteler's, originally due to Bessel, whereby the influence of internal friction was considered. This, so far, modifies the results obtained by Lommel, that no widening of the lines is indicated, and the change in the absorption-lines is different from that of the emission-lines. The author concludes with an interesting discussion of the application of these changes of spectral lines to the explanation of new stars, etc. C. P. B.

1215. *Wave-length of Mercury Rays.* **Ch. Fabry** and **A. Perot.** (Comptes Rendus, 126. pp. 1706–1708, 1898.)—Measurements have been made by an interferential spectroscope (Comptes Rendus, 126. pp. 34, 331, 407) by the method of counting the number of coincidences in a given length (up to 32 mm.). Michelson's measurements of the cadmium rays were taken as standard. The rays of mercury are two in the yellow, one in the green: the less refrangible of the yellow is double, with the minor component above the principal one by $\Delta\lambda/\lambda = -22{\cdot}5 \times 10^{-6}$; the other yellow ray has a minor component below the principal by $\Delta\lambda/\lambda = 8{\cdot}3 \times 10^{-6}$. The results are, in air at 15° and 760 mm.:—

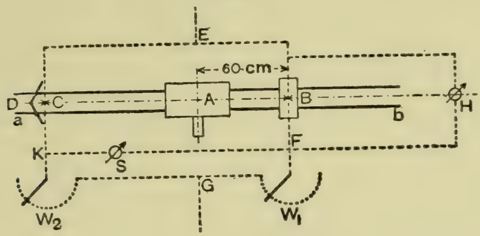
1st yellow ray ...... $\lambda = 0{\cdot}57906593\ \mu$.
2nd ,, ... $\lambda = 0{\cdot}57695984\ \mu$.
Green ray .... $\lambda = 0{\cdot}54607427\ \mu$. R. A. L.

1216. *Astigmatism.* **R. Straubel.** (Annal. Phys. Chem. 64. 4. pp. 794–808, 1898.)—Two cylindrical lenses are arranged in such a way that the astigmatism of the combination is variable; they can be turned against one another in their plane. If the axes of the two lenses are parallel, the combination acts like a plane plate; if crossed, in one direction, as a convex lens; if in the other direction at right angles to the former, as a concave lens. The astigmatic difference, *i. e.* the difference of the reciprocals of the two main radii of curvature would be double that of a single lens. The paper is mathematical. The combination may be applied for three purposes:—Firstly, for the production and demonstration of astigmatism. Secondly, for its compensation in the eye or in optical instruments; neither of these applications will be easy unless the defects be regular. Thirdly, for the determination of astigmatism of the eye and for the examination of deformed surfaces. H. B.

1217. *Photometry of Incandescent Lamps.* (Electrician, 41. p. 426, 1898.)—The rules for the photometry of incandescent lamps approved by the Verband Deutscher Elektrotechniker are as follows:—By candle-power is understood the mean candle-

power in the plane perpendicular to the axis of the lamp. This is determined by the arrangement sketched in the accompanying figure; *a*, *b* represents a straight photometer bench, 2·5 metres long; A the photometer; B an auxiliary source of light; C the lamp to be tested or the standard lamp; and D a pair of mirrors placed at an angle of 120°. The distance between A and B is 60 cm., and must be adjustable to 6 cm. longer or shorter. The mirrors are two square pieces of good, flat, silvered glass, 13 cm. side. The vertical line between the mirrors is placed so that its distance from the axis of the lamp C is 9 cm. The axis of the lamp is to be vertical, and the ends of the filament must

Fig. 1.



lie in a plane perpendicular to the axis of the photometer. The photometer-scale is to be divided into tenths of a candle-power. The photometer-screen is to be protected from outside sources of light by black screens, preferably of velvet; but the lamps, or their reflection, must not be screened in any way.

As standards, lamps taking 3·5 to 4·5 watts per candle-power are used, which have approximately the same voltage and exactly the same candle-power as the lamp to be tested should have. The auxiliary source of light should be a faultless 10 c.p. lamp, also for approximately the same voltage. To avoid changes in the candle-power it is advisable to burn these lamps 20 to 30 hours before use.

For the measurement of the pressure the two circuits EFG and EKG are connected in parallel, the one including the lamp B and the adjustable resistance W_1, the other the lamp C and the adjustable resistance W_2. Between K and F a voltmeter for measuring small pressures is placed, and a voltmeter H is connected to B, to enable the required pressure to be maintained at the terminals of this lamp by altering the adjustable resistance W_1. The voltmeter S indicates the difference in the voltage between the two lamps, and is adjusted by the resistance W_2.

To take measurements, the auxiliary lamp B is first given the correct pressure. The standard is then placed at C and the photometer-screen is placed at a distance corresponding to the standard and a balance is obtained by moving B. The distance AB is then kept constant, and a balance is obtained with the lamp to be tested placed at C. W. G. R.

1218. *Kathode and Röntgen Radiations.* **A. A. C. Swinton.** (Royal Institution Discourse, Feb. 4th, 1898; Electrician, 41. pp. 246–248, and pp. 317–319, 1898.)—A pear-shaped Crookes' tube is suspended over a straight electro-magnet, towards one pole of which the kathode beam is projected. When the magnet is excited, the beam is drawn down to a fine point, which rapidly erodes the internal glass surface of the tube. By moving the tube or the magnet, any desired pattern can be engraved on the glass. In another experiment two concave kathodes are arranged to focus on a small piece of quicklime, placed between them. The kathodes are supplied with alternating current at about 20,000 volts, and a very brilliant and beautiful light is produced by the incandescence of the quicklime. The light is found to fluctuate in a curious manner, and after a short time the kathode rays bore perfectly straight and very minute holes, right through the lime. It may eventually be found possible to produce commercial high voltage lamps on this principle of much higher efficiency than filament lamps, and possibly even rivalling arc lamps. The luminous material in this case need not be a conductor, and there is therefore a much wider range of available refractory substances. An electric furnace might also be constructed on these lines, for delicate chemical investigations.

A tube is described in which, in addition to a concave kathode and anode arranged as in a focus tube, there is a delicately pivoted wheel, with mica vanes, which can be moved bodily either out into the centre of the tube, so that the kathode stream impinges upon the vanes, or back into an annex, when the vanes are quite outside the kathode line of fire. In the former position, as in Crookes' experiments, the wheel revolves very rapidly in a direction that indicates a stream of particles proceeding from the kathode, but when placed in the latter position the wheel is found to rotate more slowly in the opposite direction. It appears, therefore, that in a focus tube, while the kathode stream proceeds at great velocity through the centre of the bulb, there is also a slower reverse stream of particles returning from the anode to the kathode, round the outside of the kathode stream.

When the stream from a concave kathode is caused to impinge upon an anti-kathode of carbon, the latter becomes luminescent where struck. If the anti-kathode be so placed as to intersect either the convergent or divergent cones of rays, these, instead of producing a uniformly luminous patch upon the carbon, produce a bright ring with a dark interior. The diameter of the ring is smaller the higher the exhaustion and the nearer to the focus the point of intersection. From this it appears that the convergent and divergent cones of kathode rays are hollow in section.

Birkeland's kathode-ray spectrum, produced by deflecting a thin kathode stream by a magnet, and then allowing it to fall upon the glass walls of the tube, can be photographed by binding a strip of sensitive photographic film round the tube, and making a single discharge through the latter. Further, by inserting between the

glass and the film a piece of black paper, so placed as to cover only one-half of the spectrum, a photograph can be obtained, one half of which is due to the visible fluorescence of the glass and the other half to the invisible Röntgen rays. Such photographs show that the bands in the spectrum produced by the Röntgen rays are co-terminous with the fluorescent bands. It is suggested that the bands are due to kathode rays of different velocities, due to the oscillatory character of the discharge, those that travel fastest being the least deflected, and the most active in producing Röntgen rays.

When a focus-tube is fitted with two or more kathodes of different diameters, but all arranged to focus upon the same anti-kathode, it is found that for any given degree of vacuum the smaller the kathode put into use the greater is the E.M.F. required to cause a discharge to pass through the tube, and the more penetrative are the Röntgen rays produced. With a tube fitted with a movable anti-kathode, half of platinum and half of aluminium, either of which can be brought opposite to the kathode at will, platinum is found to give the most rays; while similar experiments with other metals show that the metals of the highest atomic weight form the best anti-kathodes. This is in accordance with what would be expected, if the Röntgen rays are due to sudden change in velocity of the kathode-ray atoms by collision with the anti-kathode.

The resistance of a tube, and the penetrative quality of the Röntgen rays produced, can be varied by making the anode (which also forms the anti-kathode) movable, when the nearer it is placed to the kathode the higher will be the resistance and the more penetrative the rays. According to another plan, the anode is fixed and the kathode is made movable relatively to the glass walls of a conical annex to the tube, when the nearer the kathode is to the glass the higher is the resistance and the more penetrative are the rays; or instead of making the kathode movable, a conical shield of glass is arranged so as to be adjustable relatively to the kathode, with a similar result. It is suggested that the increase of resistance in each case leads to a greater velocity of the kathode stream, and thus causes the Röntgen rays to be more penetrative. Curves showing the variations in resistance, and photographs illustrating the effect on the penetrative quality of the rays are given in the paper.

By means of pin-hole photography, the exact position, dimensions, and shape of the active area of the anti-kathode, from which the Röntgen rays proceed, can be investigated, and such photographs show that in a focus-tube the active area is a small spot, either alone or surrounded by a hollow elliptical ring of larger or less dimensions, depending upon the distance beyond the focus at which the anti-kathode intersects the kathode stream.

The photographic effect of the most powerful Röntgen rays that can be produced is relatively very feeble. A comparative test of a very good Röntgen-ray tube screened with black paper, as against

a naked standard candle, showed that the candle was sixty times more active, photographically, than the tube.

The paper concludes with the suggestion that though Lodge was not able to detect any movement of the ether due to dragging a body through it, the very great velocity of the kathode-ray particles may have this effect, with the result that something analogous to the crack of a whip or a clap of the hands is produced as each particle hits the anti-kathode and rebounds; or the effect may be simply due to the enormous temperature attained by the kathode-ray particles on their kinetic energy being converted into heat in their collision with the anti-kathode, the energy, if all converted to heat in the particles themselves, being calculated to give a temperature rise of some 50,000,000,000 degrees Centigrade. AUTHOR.

1219. *Passage of Röntgen Rays along Opaque Tubes.* **E. Villari.** (Roma R. Accad. Lincei, Atti, 7. pp. 225–230, 1898.)—When sent along opaque tubes they neither gain nor lose in photographic effect, and accordingly they seem not to be sensibly reflected or diffused within the tube; and they probably do not lose any of their discharging power. A. D.

1220. *Röntgen Radiation and the Luminescence of Gases.* **A. v. Hemptinne.** (Zeitschr. Phys. Chem. 26. pp. 165–169, 1898.)—The author investigates the property of Röntgen rays of enabling a Geissler tube, through which they are passed, to give out light under a much lower vacuum. Therry suggested that the effect of Röntgen rays is not due to their ionising effect (at any rate primarily), but to the rays acting upon the ether in such a way as to facilitate electric discharge-sparks between molecules, the production of milliards of which sparks is the cause of luminescence of the gas. Luminescent gas is very like a metallic conductor in many ways, even including a screening effect; but it does not absorb Röntgen rays, as metals do. A. D.

1221. *Vacuum-Tubes that can be Regenerated.* **P. Villard.** (Comptes Rendus, 126. pp. 1413–1414, 1898.)—Affix a closed platinum tube to the Crookes tube. Exhaust to a high vacuum and seal. Heat the platinum tube for two or three seconds in a Bunsen flame: hydrogen traverses the platinum; air does not in the least. Five minutes of this will make the vacuum so low that the tube will not even act as a Geissler. By heating the platinum tube, protecting it from the Bunsen-flame gases, the process is reversed, and the vacuum may become so high that discharges from a powerful Ruhmkorff will not pass through it. Platinum-iridium, palladium, nickel, and even iron will act in a similar way. A. D.

1222. *Fluorescent Screens.* **P. Villard.** (Comptes Rendus, 126. pp. 1414–1415, 1898.)—If a portion of a barium platinocyanide screen be sheltered from Röntgen rays which impinge on the rest of it, and if the intervening obstacle be then removed,

the part previously sheltered is now more brightly fluorescent than the remainder of the screen. A shadow-picture may thus be obtained when the object is removed. In full light it can be seen that the exposed portion is darkened as compared with the sheltered part; but this darkening disappears on exposure to daylight, and along with it the power of producing these shadow-pictures. It persists, however, if the affected screen be kept in the dark; and therefore such screens should not be put away in darkness after use. A. D.

1223. *Thorium Rays.* **G. C. Schmidt.** (Annal. Phys. Chem. 65. 1. pp. 141–151, 1898.)—Thorium and its compounds emit rays whose properties are identical with those of Becquerel's uranium rays, except that they are not polarised by tourmaline. The properties of the two kinds of rays are probably connected with their exceptionally high atomic weights, since no other metals emit them. Both uranium and thorium rays are refracted by glass. They affect the photographic plate, and impart a temporary conductivity to air. The latter property is not shared by the "rays" emitted by zinc, resin, and other substances, which are probably due to vaporisation. E. E. F.

1224. *Radiations from Compounds of Uranium and of Thorium.* **Sklodowska-Curie.** (Comptes Rendus, 126. pp. 1101–1103, 1898.)—All the compounds of uranium behave like uranium, and the more so the more uranium they contain. Oxide of thorium is more powerful than uranium itself. Uranium and thorium have the two highest atomic weights. Cerium, niobium, and tantalum compounds are slightly active. Yellow phosphorus is very active, perhaps from some other cause; red phosphorus and phosphates are not at all so. Pitch-blende (oxide of uranium) is more powerful than the metal itself; so is natural chalcolite (phosphate of copper and uranium), while artificial chalcolite is not: it seems as if these, as minerals, contained some element more powerful than uranium. The effects produced increase with the thickness of the material: much more so with thoria than with uranium. The radiations from thorium compounds are more powerfully absorbed by aluminium than those from uranium compounds; and the thicker the thoria layer the less absorbed are the rays from it. Thorium radiations have less photographic effect than uranium radiations. All these radiations are very much like Sagnac's secondary radiations. It is as if all space were constantly traversed by Röntgen rays of very high penetrative power only revealed by their being transformed into secondary radiations upon impinging on elements of very high atomic weight. A. D.

1225. *Radiations from Thoria.* **G. C. Schmidt.** (Comptes Rendus, 126. p. 1264, 1898.)—Results, as regards thoria compounds, like those of Mme. Sklodowska-Curie (Abstract No. 1224), and prior to hers. A. D.

1226. *Radiations from Uraninite.* **E. Villari.** (Écl. Électr. 15. pp. 32–33, 1898; Rend. della R. Accad. di Napoli, 1897.)—Uraninite gives off radiations similar to those from uranium and its salts. Air exposed to it will discharge a conductor, but cannot then discharge another of the same sign, though it will discharge one of opposite sign. Air exposed to uraninite is brought back to its natural condition by being passed between the plates of a charged condenser. The electric effect is not able to traverse cardboard as well as that of radiations from uranium, if at all.

A. D.

1227. *Phosphorescence in Low-Vacuum Tubes.* **F. Campanile** and **E. Stromei.** (N. Cimento, 4. 6. pp. 417–421, 1897.)—Phosphorescence in Geissler tubes is explained as being due to gradual charging and extremely rapid discharging of the walls of the tube at the part covered externally by the anodic tinfoil; the phosphorescence being set up on the opposite walls during the extremely rapid discharge. A. D.

HEAT.

1228. *Thermodynamics of a System which can exist in different States. I. Systems depending on a Single Normal Variable. II. Transformations of Sulphur. III. General Theory.* **P. Duhem.** (Zeitschr. Phys. Chem. 22. pp. 545–589; 23. pp. 193–266 & 497–541, 1897; Mém. de l'Acad. roy. de Belgique, 54. 1896.)—Imagine a system able to undergo continuous changes of equilibrium which are not reversible; from ordinary thermodynamics we can credit it with intrinsic energy E only, and assumptions are necessary to further progress. In the simplest case such a system would be defined by the absolute temperature T and a normal variable x, the work done *on* it during an infinitesimal change being therefore expressible in the form $\mathrm{X}dx$ (the normality of x consisting in this work being independent of $d\mathrm{T}$). Duhem then *assumes* that single-valued and continuous functions $\mathfrak{f}(x, \mathrm{T})$ and $f(x, \mathrm{T}, \mathrm{X})$ exist such that

$$\mathrm{E} = \mathfrak{f} - \mathrm{T}\partial\mathfrak{f}/\partial\mathrm{T},$$
$$d\mathrm{X} = (\partial^2\mathfrak{f}/\partial x^2)dx + (\partial^2\mathfrak{f}/\partial x\partial\mathrm{T})d\mathrm{T} + f|dx|,$$

where $|dx|$ denotes the absolute value of dx regardless of sign. (If $f=0$, then $\mathfrak{f}$ is the thermodynamic potential of the system, and may so be called in this more general case.) Through every point then on an xX-diagram, two isothermals pass characterised by

$$(\partial\mathrm{X}/\partial x)_\mathrm{T} = \partial^2\mathfrak{f}/\partial x^2 \pm f,$$

the upper sign referring exclusively to increasing, and the lower sign to decreasing values of x; and it is further *assumed* that for all realisable isothermal variations $(\partial\mathrm{X}/\partial x)_\mathrm{T} > 0$, which also gives $\partial^2\mathfrak{f}/\partial x^2 > 0$. Similarly through every point on an xT-diagram pass two iso-X lines given by

$$(\partial x/\partial\mathrm{T})_\mathrm{X} = -(\partial^2\mathfrak{f}/\partial x\partial\mathrm{T})/(\partial^2\mathfrak{f}/\partial x^2 \pm f),$$

wherein the upper and lower signs refer exclusively to increasing and decreasing values of x respectively; and it is further *assumed* that for all realisable iso-X variations $\lambda(\partial x/\partial\mathrm{T})_\mathrm{X} > 0$, and consequently $\lambda\partial^2\mathfrak{f}/\partial x\partial\mathrm{T} > 0$, where

$$\lambda(x, \mathrm{T}, \mathrm{X}) \equiv \partial\mathrm{E}/\partial x - \mathrm{X}$$

represents the heat added per unit alteration of x without change of T or X. The trend of the iso-X lines thus depends on the sign of λ.

For any finite variation we obtain by integration

$$\mathrm{X}_1 - \mathrm{X}_0 = (\partial\mathfrak{f}/\partial x)_1 - (\partial\mathfrak{f}/\partial x)_0 + \Sigma f|dx|,$$

and consequently a necessary condition for a closed cycle (*i. e.* with the same initial and final values of x, X, T) is

$$\Sigma f|dx| = 0:$$

all closed cycles must therefore cut the surface $f=0$ in an even number of points unless they lie wholly upon it. This surface is taken to represent the *natural* states of the system, which is characterised as of the First or Second Kind according as $\partial f/\partial x \gtreqless 0$ when $f=0$; and the stability of systems of the first kind and the instability of those of the second, under physically constant temperature and external conditions, is demonstrated. The isothermal and iso-X transformations of these systems are then considered in detail, and the conditions of their satisfying Clausius' law $\int dQ/T < 0$ investigated, the special cases of pseudo-reversible processes entirely in the surface $f=0$, and of the actually reversible processes wherein x remains constant being separately treated.

In Part II. this theory is somewhat generalised for systems subjected to a uniform hydrostatic pressure, whose characterisation depends on a variable x in addition to p, v, T, and the isopiestic variations of such a system with temperature are discussed at length. The theory is then successfully applied to account in all respects for the peculiar behaviour of the different allotropic forms of sulphur, including the so-called mother-of-pearl variety, which Gernez has experimentally investigated. In this application any specimen of sulphur is assumed to be a mixture of two allotropic forms, one of which is soluble and the other insoluble in CS_2, and x is taken as the ratio of the mass in the latter form to that in the former.

In Part III. the theory is generalised for n normal variables, the laws of the variations of state produced by changes of temperature and of the external conditions are deduced, and general propositions are arrived at which in all points are similar to those that have long been known, from ordinary thermodynamics, to hold for systems which are not subject to permanent deformations. R. E. B.

1229. *Mechanical Theory of Heat.* **W. Stekloff.** (Comptes Rendus, 126. pp. 1022–1025, 1898.)—In a space D bounded by a surface S of definite curvature at every point, there is an infinity of positive numbers μ_s ($s=1, 2 \ldots$) and corresponding functions V_s satisfying the conditions

$$\frac{\partial^2 V_s}{\partial x^2}+\frac{\partial^2 V_s}{\partial y^2}+\frac{\partial^2 V_s}{\partial z^2}+\mu_s V_s = 0 \text{ within the space D,}$$

and

$$\frac{\partial V_s}{\partial n}+hV_s = 0 \text{ over the surface S,}$$

where n is the direction of the normal to S exteriorly, and h is a positive constant. If then f be a finite function, continuous within D with its derivatives of the first three orders

and satisfying the equation of radiation over the surface S, f is developable in an absolutely convergent series proceeding according to the functions V_s. A. D.

1230. *Thermometry.* **C. Chree.** (Phil. Mag. 45. pp. 205–227, 299–325, 1898.)—An excellent discussion of the measurement of temperature by means of glass thermometers is here presented, in which are treated the zero-difficulties and lag due to the behaviour of glass, the methods of measurement with fixed and movable zeros, and the limits of accuracy of temperature-determination. In connection with these the subject of calibration is touched upon, and the special difficulties in the determination of the fixed points, and the allowances to be made for the emergent column and for external and internal pressure are discussed at length, as is also Welsh's method of graduation. This paper should be studied by those who rely upon glass thermometers for accuracy, and are not acquainted with Guillaume's 'Thermométrie de Précision,' or the work of the Bureau International, or of the Charlottenburg Reichsanstalt. R. E. B.

1231. *Dalton's Law for Mixed Gases.* **D. Berthelot.** (Comptes Rendus, 126. pp. 1703–1706, & pp. 1857–1858, 1898.) **Van der Waals.** (Comptes Rendus, 126. pp. 1856–1857, 1898.) **A. Leduc.** (Comptes Rendus, 126. p. 1859, 1898.)—Dalton's formulation of the law for gaseous mixtures was that the sum of the partial pressures is equal to the total pressure; this gives less accurate results than the alternative expression adopted by Sarrau, that the specific volume of a gaseous mixture is the (weighted) mean between the specific volumes of the components. The latter form is true for the "permanent" gases, and approximately for mixtures of two gases having nearly the same compressibility (*e.g.* N_2O and SO_2). D. Berthelot finds that very exact results may be obtained, starting from van der Waals' equation

$$\left(p+\frac{\alpha}{v^2}\right)(v-\beta)=R_1T$$

for each simple gas, and representing the behaviour of the mixture by an equation of the same form with the constants A, B, R, where

$$B=\frac{p\beta+q\beta'}{p+q},$$

$$A=\frac{p^2\alpha+2pq\sqrt{\alpha\alpha'}+q^2\alpha'}{(p+q)^2},$$

$$R_1T=p+q,$$

p and q being the number of gram-molecules of the two gases respectively (p in the first equation above is the pressure).

Constants are given for the gases H_2, N_2, O_2, CO_2, N_2O, SO_2; and it is shown that the formulæ give results within the limit of error of experiment in various cases quoted, while Dalton's and Sarrau's experiments are very appreciably in error.

Van der Waals points out that the molecular theory leads to the above results, only with an undetermined coefficient, a_{12}, which Berthelot sets $= \sqrt{a_1 a_2}$: if it has this value, that is a purely empirical result.

Leduc mentions two cases in which Berthelot's formula gives less satisfactory results. R. A. L.

1232. *Compressibility of Gaseous Mixtures.* **E. H. Amagat.** (Comptes Rendus, 127. pp. 88–90, 1898.)—In 1880 the author had found that, up to 400 atmospheres, the volume of atmospheric air under any pressure is equal to the sum of the volumes of its constituents at the same pressure and temperature. The following table, calculated from his more recent experiments, shows that this law holds up to 3000 atmospheres at 0°. In the table (N+O) is the sum of the volumes occupied by 0·79 vol. of nitrogen and 0·21 vol. of oxygen (measured at 0° and 1 atmo.) when exposed separately to the pressures given in the first column, whilst A is the corresponding value for 1 vol. of air.

Pressure (atmos).	(N+O).	A.	Percentage difference.
100	0·009774	0·009730	+0·45
200	0·005063	0·005050	+0·26
300	0·003664	0·003658	+0·16
400	0·003034	0·003036	−0·06
500	0·002682	0·002680	+0·08
600	0·002453	0·002450	+0·12
700	0·002292	0·002291	+0·05
800	0·002174	0·002171	+0·14
900	0·002078	0·002075	+0·14
1000	0·002000	0·001999	+0·05
1200	0·001881	0·001883	−0·11
1400	0·001791	0·001792	−0·06
1600	0·001720	0·001721	−0·06
1800	0·001659	0·001662	−0·02
2000	0·001610	0·001613	−0·18
2200	0·001568	0·001570	−0·13
2400	0·001533	0·001534	−0·06
2600	0·001503	0·001500	+0·02
2800	0·001476	0·001469	+0·47
3000	0·001465	0·001455	+0·62

There are no data available by which the law may be tested for other gases near their critical points. T. E.

1233. *Reduction to normal degrees C. of Pt-temperatures on Dewar and Fleming's Thermometer* "P_1." **J. D. H. Dickson.** (Phil. Mag. 45. pp. 525–528, 1898.)—A table for every 5 *pt*-degrees from 100° to −283° is calculated from the formulæ

$$R = \cdot 010975\,(pt + 283\cdot 0),$$

$$(R + 20\cdot 529023)^2 = \cdot 53270015\ (t + 1048\cdot 4396).$$

[This is equivalent to $t = 0\cdot 000226113(pt + 4306\cdot 85)(pt + 0\cdot 21)$.]

R. E. B.

1234. *Specific Heat of Air at Constant Pressure.* **A. Leduc.** (Comptes Rendus, 126. pp. 1860–1861, 1898.)—The author has discovered an error in Regnault's measurement. Regnault found that the expansion of the air in his experiments, in passing from the heater to the calorimeter, absorbed $\frac{1}{160}$ of the heat given out to the calorimeter; yet he ignored this quantity in recording his results. If it be taken into account, the specific heat becomes 0·239, in exact accordance with the result found by E. Wiedemann.

R. A. L.

1235. *Spheroidal State.* **J. Stark.** (Annal. Phys. Chem. 65. 2. pp. 306–310, 1898.)—The author considers fully in this paper the conditions present in a drop of liquid when in the spheroidal state on a hot plate, and explains by means of these all the phenomena which have yet been noticed in this connection. The want of complete electrical insulation between the drop and the plate he accounts for by oscillations of the drop, and the presence of these oscillations he verifies by placing a telephone in an electric circuit containing a battery and the gas film between the drop and the plate. The influence of different liquids and different temperatures on the noise in the telephone is noted in the paper. The well-known vortex motion noted in the drops he attributes to variation of surface-tension owing to differences of temperature at different parts of the drop. The bottom surface being hottest, has least surface-tension and therefore tends to extend. This causes a circulatory motion of the liquid surface, from the centre outwards in the bottom surface and towards the centre in the upper surface.

J. B. H.

ELECTRICITY.

1236. *Irreversible Radiation Phenomena.* **L. Boltzmann.** (Berlin. Akad. Sitzber. 12. pp. 182–187, 1898.)—Planck in his communication, 16th December, 1897, defined the reverse of a given process or course as follows, viz., the time t before the reversal in the original course is *the corresponding time* to t after the reversal in the reversed course. Then the electric forces have at corresponding times the same sign and value in the reversed and in the original course. The magnetic forces, with the same absolute value, have at any time t in the reversed course the opposite sign to that which they had at the corresponding time in the original course. Boltzmann accepts that definition.

Planck considers a hollow sphere in which a system of electric waves is set up, and there is an electric resonator at the centre. The motion is defined by the equation

$$F = \frac{\phi\left(t - \frac{r}{c}\right) + f\left(t - \frac{r}{c}\right) - \phi\left(t + \frac{r}{c}\right)}{r},$$

r being the distance of any point from the centre. The term $f\left(t - \frac{r}{c}\right)$ relates to the electric moment of the resonator.

If the subscript u refer to the reversed motion, then, if it be a true reversal, we must have

$$\phi_u\left(t - \frac{r}{c}\right) + f_u\left(t - \frac{r}{c}\right) - \phi_u\left(t + \frac{r}{c}\right)$$
$$= \phi\left(-t - \frac{r}{c}\right) + f\left(-t - \frac{r}{c}\right) - \phi\left(-t - \frac{r}{c}\right);$$

and in order that this may be true for all values of r and c we require

$$\phi_u(\omega) = -\phi(-\omega) - f(-\omega)$$

for any whatever argument ω.

Planck now defines two motions, viz.:—

A. $$f(t) = -2D \sin(k\pi) \sin\left(\frac{2k\pi t}{T} + \pi k - \theta\right),$$
$$\phi(t) = D \cos\left(\frac{2k\pi t}{T} - \theta\right);$$

B. $$f_u(t) = 2D \sin(k\pi) \sin\left(\frac{2k\pi t}{T} - \pi k + \theta\right),$$
$$\phi_u(t) = -D \cos\left(\frac{2k\pi t}{T} + \theta\right),$$

of which B is, according to Planck, the reversal of A. But the values of $f_u(t)$ and $\phi_u(t)$ given by B do not satisfy equation (b), and therefore B is not the true reversal of A. Now B does not satisfy Planck's necessary conditions, and is therefore, Planck argues, an impossible motion.

According to Planck, if the motion be reversed, the reversed motion does not satisfy the conditions, and is therefore impossible. According to Boltzmann, that is because the motion B which Planck takes for the reversed motion is not accurately such. If instead of Planck's equations for the second motion we use the complete equations, it satisfies all necessary conditions.

[For previous papers, see Abstracts Nos. 630 and 631, and Phys. Soc. Abstracts, No. 651, 1897.] S. H. B.

1237. *Validity of Maxwell's Equations.* **A. Scheye.** (Zeitschr. Phys. Chem. 26. pp. 159–160, 1898.)—In this note the author defends Maxwell's Electromagnetic Equations against the attack made upon them by Wedell-Wedellsborg in an article bearing the title of this abstract, and published in the Zeitschr. Phys. Chem. 24. 367 (1897). E. H. B.

1238. *Theory of Galvanism and Heat.* **E. Riecke.** (Göttingen Nachrichten, 1. pp. 48–70, 1898.)—The author expresses the view that the older—or pre-Maxwell—Theory of Electricity, due to Coulomb, Ampère, and W. Weber, is likely to acquire renewed importance in the treatment of electrolysis and the theory of ions; and he refers to the writings of Christiansen, Giese, and H. A. Lorenz, whose theory is based on the ions. In the present paper the writer, following W. Weber, holds that the conduction of electricity and of heat in metals takes place in a way not different in principle from electrolysis. In the space between the ponderable molecules are moving not only positive but also negative electric particles.

1. Considering first conduction of heat, he supposes a cylinder of metal parallel to the z axis. The temperature increases with z. The law of conduction of heat is then

$$\mathfrak{W} = -k\frac{d\mathrm{T}}{dz}.$$

This is accompanied by a galvanic current, whose strength in electromagnetic measure is

$$\begin{aligned}\gamma &= -\omega k\frac{d\mathrm{T}}{dz}\\ &= -\omega\mathfrak{W}.\end{aligned}$$

The factor ω is defined as the "Mitführungszahl" for electricity, which I propose to translate "coefficient of the attendant current."

2. He treats the galvanic current as the principal one, and finds an "attendant current" of heat.

In the remaining articles he treats on the same principle :—

3. The relation between the constants of conduction of heat and of electricity.
4. The theory of the attendant current in thermoelectrity.
5. The Peltier effect.
6. The Thomson effect.
7. The thermoelectric circuit and the second law of thermodynamics.
8. The process which goes on at the junction of two metals.
9. The more general formulæ of thermoelectricity.
10. Galvano-magnetic action.
10. Thermo-magnetic action.
12. Simplification of the formulæ for galvano-magnetic and thermo-magnetic action. S. H. B.

1239. *Energy of an Electrified System.* **H. Pellat** and **P. Sacerdote.** (Comptes Rendus, 126. pp. 817–820, 1898.)—A discussion is given of the excess of energy (considered as seated in the dielectric) of a system of conductors and dielectrics, due to their electrification. The dielectric is regarded as homogeneous and isotropic, and the conductors and dielectric are supposed to have the same expansion. The result reached is that the excess of energy

$$=\int\left(1+\lambda T+\frac{T}{K}\frac{\partial K}{\partial T}\right)\frac{K\phi^2}{8\pi}\,.\,dv,$$

where λ is the linear coefficient of expansion of the dielectric, T the temperature, K the specific inductive capacity, and ϕ the intensity of the electric field in the volume dv of the dielectric. The energy per unit volume acquired by the dielectric owing to the charging of the system, the temperature remaining the same, is not $\frac{K\phi^2}{8\pi}$, but $\left(1+\lambda T+\frac{T}{K}\frac{\partial K}{\partial T}\right)\frac{K\phi^2}{8\pi}$. J. J. S.

1240. *Imaginary Electrical Quantities.* **H. Pellat.** (Écl. Électr. 15. pp. 221–228, 1898.)—In this treatment of the application of the complex variable to alternating-current problems the author assumes (1) that all impressed E.M.F.'s have the same periodic time, and (2) that the coefficients of self-induction are constant. It is also assumed that all the alternating electrical quantities may be represented by a sine curve. It is found that for a resistance R, capacity C, and self-induction L in series, the charge, Q, on the condenser is given by

$$L\frac{d^2Q}{dt^2}+R\frac{dQ}{dt}+\frac{Q}{C}=(Ee^{\Phi k}+ue^{\psi k})e^{kpt},$$

where u is the maximum value of the potential difference applied between the terminals of the circuit, and E the maximum value

of any internal E.M.F., $k = \sqrt{-1}$, and $p = 2\pi n$, n being the frequency. The solution of the above equation gives

$$Q = \frac{Ee^{k(pt+\phi)} + ue^{k(pt+\psi)}}{-Lp^2 + \frac{1}{C} + kpR},$$

whence the current i is given by

$$i = \frac{dQ}{dt} = \frac{kp\{Ee^{k(pt+\phi)} + ue^{k(pt+\psi)}\}}{-Lp^2 + \frac{1}{C} + kpR}$$

$$= \frac{Ee^{k(pt+\phi)} + ue^{k(pt+\psi)}}{\rho},$$

where

$$\rho = R + k\left(Lp - \frac{1}{Cp}\right);$$

ρ is the impedance of the circuit, and when multiplied by the current i gives the E.M.F.

The author then proceeds to deduce Kirchhoff's laws as applied to alternating-current circuits, and finds that at a junction in a network of conductors

$$\Sigma i = 0,$$

and round any closed circuit

$$\Sigma i\rho = E,$$

where E is the total E.M.F. in the circuit.

The paper contains also some interesting applications of the method of the complex variable. W. G. R.

1241. *Rotation of Insulators in Magnetic Field.* **H. Benndorf.** (Wien. Akad. Sitzber. 106. pp. 1075–1084, 1897.)—After referring to Duane and Stewart's investigations on this subject [see Phys. Soc. Abstracts, No. 665, 1896, and No. 615, 1897], the author challenges a conclusion arrived at in a recent paper by A. Campetti, in which the latter states that by using a magnetic field of sufficient intensity the energy of electric polarisation may be so far increased as to become comparable with the kinetic energy of the rotating insulator, and that the damping observed by Duane may be ascribed to this fact. The author states that he has investigated the problem from a theoretical standpoint, and arrived at an expression for the electric energy which is identical with that obtained by Campetti. Hence he concludes that the latter has either not attempted to calculate the field-intensity required to bring about the result stated, or else has mixed up the electrostatic and electromagnetic systems of units in working out the numerical result. Campetti's theoretical investigation is next reproduced, with slight modifications. It is shown that when a sphere of radius a and dielectric constant K is rotating with angular velocity ω about an axis normal to a uniform magnetic

field of intensity H, the energy of electric polarisation in the sphere is

$$W = KH^2\omega^2a^5(1+4R^2)/60,$$

R being a proper fraction. The kinetic energy of the sphere is

$$U = \tfrac{4}{15}\pi\omega^2a^5\rho,$$

ρ being the density. Assuming that R reaches its limiting value of 1, and that $H = 10{,}000$, $\rho = 1$, we have, if K be, as usual, measured in electrostatic units,

$$W/U = \frac{K}{9.10^{13}}.$$

This proves the fallacy of Campetti's conclusion, and shows that the damping observed by Duane can never be accounted for by dielectric hysteresis. A. H.

1242. *Electric Discharge in a Magnetic Field.* **A. Broca.** (Comptes Rendus, 126. pp. 823–826, 1898.)—A further description is given of the author's experiments on discharges in tubes containing rarefied gases in intense magnetic fields. He suggests that phenomena occur analogous to that of Zeeman, and considers that the hypothesis of vibrating ions furnishes an explanation which though not a necessary is a sufficient means of coordinating the facts relative to the luminous emission of incandescent gases and those relative to the electric discharge in gaseous media.

J. J. S.

1243. *High-Frequency Gas Discharges.* **H. Ebert.** (Annal. Phys. Chem. 65. 4. pp. 761–788, 1898.)—The discharge in a vacuum-tube consists of two distinct parts. One of them is an ordinary conducting discharge, with development of Joulean heat; the other is the partial or complete breaking-down of a dielectric capacity. When high-frequency currents are employed, the latter is more emphasised in comparison with the former. Such high-frequency currents may be generated direct by an alternator, as originally employed by Tesla. The author uses a motor-alternator. The alternate-current obtained is transformed to a high potential by a hedgehog transformer. The high-potential alternate current is measured by a heated-wire ammeter, and the effective E.M.F. is measured by an aluminium plate suspended by a quartz fibre between two plates connected with the points studied. In most of the experiments, the frequency was 1000 per second, and the E.M.F. varied from 700 to 3000 volts. The discharge had a perfectly symmetrical aspect; the three kathode layers immediately adjoined both electrodes, and the red anode light lay between them. All the luminous phenomena were very intense. Analysis by means of a revolving mirror yielded the following facts:—The appearance is due to two discharges in opposite directions, which are superposed. Each discharge is complete, there being no partial discharges. In

the mirror the single discharges are divided by perfectly dark though very narrow intervals, except at very low pressures. At 2·5 mm. pressure, with 112 watts for the continuous current, 16·5 watts for the low-pressure, and 12·8 watts for the high-pressure alternate current, and with an effective E.M.F. of 958 volts, the discharge-tube consumed 9·2 watts. With longer tubes the proportion was more favourable. E. E. F.

1244. *Dark Kathode Space.* **A. Wehnelt.** (Annal. Phys. Chem. 65. 3. pp. 511–542, 1898.)—Those parts of the discharge-tube at which the dark kathode-space usually appears offer a great resistance to the development of the positive discharge. To investigate the nature of the discharge when produced within the dark space itself, the author utilises the power of rapidly damped electric oscillations to affect a coherer, or to excite slightly damped electric oscillations in a Lecher wire-system. He also uses discharge-tubes in which, by means of the barometer contrivance, the electrodes can be mutually approached to any desired extent. He finds that at the higher pressures no waves are sent out which affect the coherer, but that when the dark space envelopes the anode a totally different form of discharge sets in, which gives rise to strong electric waves, perceptible at a distance of 5 m. This result happens both when the dark space is enlarged by exhaustion so as to envelope the anode, and when the anode is mechanically introduced into the dark space. The secondary dark spaces formed at the walls near the kathode also offer a resistance to the discharge proceeding from the anode. The results are the same whether the discharge is produced by an influence-machine or by a battery of accumulators giving 2000 volts. When the anode projects into the dark space, the discharge potential rises, and the anode light turns back until it reaches the glow light outside the dark space. At the same time the potential gradient in the dark space increases. X-rays are due to the presence of rapidly-damped disruptive discharges, and are probably formed by a sudden impact of charged particles upon a solid body. E. E. F.

1245. *Kathode Rays parallel to Electric Force.* **P. Lenard.** (Annal. Phys. Chem. 65. 3. pp. 504–510, 1898.)—The extent to which a kathode beam is deflected by a given electric or magnetic field has hitherto been assumed to be invariable as long as the origin of the beam remained the same. But the emission theory of kathode rays suggests a variation which may be brought about by sending the beam along the lines of force extending between the two plates of a condenser, as may be done by perforating the condenser plates. Such a variation may be actually placed in evidence. The author uses as a generator the vacuum-tube with aluminium " window " used in his former experiments. An air-condenser, consisting of two parallel plates perforated in the

centre, is mounted in an exhausted tube attached to the window. A kathode beam emerges from the window and passes through in the direction of the lines of electric force. It is finally caught on a fluorescent screen, on which its deflection is indicated by the shifting of a spot of light. No deflection is produced by charging the perforated condenser. But when the plate next the window is charged positively, the magnetic deflection of the beam is increased. This means that the transmission of the kathode rays through an electrostatic field is in the direction of the lines of force. In one case quoted the sparking-distance in the discharge-tube was 2·8 cm., the difference of potential between the condenser-plates was 291×10^{10} C.G.S. electromagnetic units, the original velocity of the rays $0{\cdot}70 \times 10^{10}$ cm./sec., and the final velocity $0{\cdot}35 \times 10^{10}$. Hence the velocity is reduced to one-half the original amount. The most remarkable circumstance is that the electrostatic field should modify the velocity of something which is already moving at a rate comparable with the velocity of light. E. E. F.

1246. *Measurement of Electric Waves by Interference.* **P. Drude.** (Annal. Phys. Chem. 65. 3. pp. 481–498, 1898.)—V. von Lang's method of measuring the length of electric waves by sending them through the two unequal branches of a Quincke tube, and noting their interference, is unsuitable for the purpose, since the interference-tube itself contributes to determine the wave-length. As a general rule, it may be said that the wave-length indicated by the interference-tube is double the diameter of the tube itself. In the experiments of which this is the result, a coherer was employed which consisted of small iron screws, thus giving graduated reactions, instead of the highly sensitive but sudden reaction of the Marconi pattern. Instead of a tapping device, the coherer was lifted by means of a thread and allowed to drop on to its wooden support to restore the primitive resistance. E. E. F.

1247. *Absorption of Electric Waves by Water.* **P. Drude.** (Annal. Phys. Chem. 65. 3. pp. 499–503, 1898.)—The absorption by water is difficult to establish owing to the large amount of reflection at the surface. The author employs a device in which the thickness of the water layer may be varied without changing the reflection. He inserts plates of glass of different thicknesses in a trough of water with glass walls. With waves 9 cm. long it is found that the reaction of the coherer decreases with the thickness, whereas waves 60 cm. long are not perceptibly affected. The decrease might be due also to an influence of the thickness of water upon its reflective power, as in the case of Newton's rings. But this is rendered improbable by the fact that the transmission decreases continuously. The apparent absorption is greatly altered

by the presence of metallic bodies such as mirrors or tubes in the neighbourhood of the exciter. These bodies affect the wave-length.
E. E. F.

1248. *Electrical Oscillations in Wires.* **H. C. Pocklington.** (Cambridge Phil. Soc. Proc. 9. 7. pp. 324–332, 1898.)—This paper deals with electrical oscillations about perfectly conducting wires of circular cross-section. The first step is to find an expression for the electrical forces which satisfies the general differential equations and is infinite at the wire. This expression represents the forces due to an arbitrary distribution of infinitesimal Hertzian oscillators with their axes along the axis of the wire. The solution is completed by finding the form of the arbitrary function from the condition that the electric force must be normal to the wire at its surface. The problem is worked out in detail for the case of a circular wire, the period of the vibration and the damping being calculated for the case of the fundamental vibration of a thin wire. The resonance of a circular conductor is discussed. It is found that when the resonator is correctly tuned, the induced current is independent of the cross-section of the wire. The case of a helical wire is next considered. When the period of an oscillation which is being propagated along the wire is not great, two velocities of propagation are possible—one with velocity (measured along the wire) equal to that of light, the other with a greater velocity. If the period is greater than a certain finite value, the former velocity only is possible. If, however, the period is very great, the velocity of propagation along the wire is greater than that of light. In the limit the velocity along the axis of the helix is equal to the velocity of light. These results agree with Hertz's experiments on helical wires.
AUTHOR.

1249. *Insulation and Conduction.* **R. A. Fessenden.** (Amer. Instit. Elect. Engin. 15. pp. 187–204, 1898.)—*Part I.* For insulation it is necessary to have—

(1) Dielectric strength ; (2) Resistance.

The one important for power-transmitting, the other for conveying signals. Conduction is considered under four heads :—Convection, conduction in solids, in fluids, and in gases.

A. Convection supposes a small particle moving from one electrode to the other, and conveying the charge like a pith-ball swinging between electrified knobs.

It is remarked that impurities in the oil are apt to group themselves along the lines of the highest slope of potential, like iron filings on a magnet. For a convective current to take place the radius of the particles carrying the discharge must be a large fraction compared to the radius of the charged conductor.

Convection may be stopped:—

(1) By using a viscous oil;
(2) By interposing dry cellulose;
(3) By dissolving a solid non-dissociating substance of the oil so as to obtain a gelatinous mass, for example paraffin (which has an additional value from its high specific heat of liquefaction).

The effect of points in promoting convection is two-fold:—

(1) Repulsive force varies as the square of the density, which is high at a point: and
(2) Particles will not take the charge away unless their radius be large compared to that of the charged conductor.

B. Conduction in solids is not yet quite determined to be convection, though the conductivities of metals are in proportion to the quantity

$$\sqrt{\frac{\text{elasticity}}{\text{density}}} + \text{valency}.$$

This formula is analogous to that for the velocity of sound in a body, thus corresponding to the fact that in the convective discharge electricity moves with the same velocity as that with which the ions move. This would probably have been observed long ago had the writer's discovery, as expressed in the following formula, heen known:

$$\text{Young's modulus equals } \frac{78 \times 10^{12}}{(\text{atom. vol.})^2};$$

whence the velocity of sound in wires cms. per sec. equals

$$\frac{883 \times 10^4}{\text{atom. vol.} \times \sqrt{\text{density}}};$$

and the electric resistivity approximately equals

$$45 \times 10^{-9} \times \text{atom. vol.} \times \sqrt{\text{density}} \times \text{valency}.$$

It would appear, then, that the dielectric strain is propagated with the velocity of light $\sqrt{K\mu}$; whereas the actual electricity in the wire moves with that of sound proportional to $\sqrt{\frac{K}{\mu}}$.

The metals are arranged in a Newland's chart to compare their mechanical and electrical properties. The chart is modified to show that metalloids tend to polymerisation from their higher valencies.

The author is inclined to believe that increased resistance accompanies polymerisation, and that polymerisation varies as the valency, in fact anything which tends to give molecular complexity tends to give high resistance. Hence we see that alloys are

higher in resistance than the average of their components. It is also hoped to prove that the conductivities are in the same ratio as the velocities of very short sound waves, from the consideration that when the period of sound-waves coincides with that of the molecules it is a heat-wave, and that heat is transmitted with the velocity of short sound-waves, but with a large logarithmic decrement.

C. *Conductivity of Fluids.*—The author prefers to state the law of osmosis as follows:—Dissolved substances give an osmotic suction per square cm. which is equal numerically to the kinetic pressure which the substance would have if it were turned into a gas at the same temperature and volume as the solution. It is found that only those salts which are dissociated when in solution can conduct electricity. Hence the conductivity of solution depends on—

(1) The attraction of the molecules of the solvent for the ions of the solute;
(2) How fast the ions move;
(3) The valency of the ions.

D. *Conductivity of Gases.*—This is thought to be electrolytic, though points are given in favour of convection.

[For the second part of this paper see Abstract No. 1273.]

M. O'G.

1250. *Conductivity of Thin Sheets of Silver.* **G. Vincent.** (Comptes Rendus, 126. pp. 820–823, 1898.)—The experiments were carried out with thin layers of silver deposited chemically on carefully cleaned plates of glass. The thickness of each sheet was determined by Wiener's method, which depends on the transformation of silver into iodide. The limits of thickness in the experiments were 38 μ and 170 μ. On taking as abscissæ the thickness, ϵ, of the silver and as ordinates the conductivity $\frac{1}{\rho}$, a straight line is obtained when the thickness $\epsilon = 50\ \mu$ or above. This straight line passes below the origin and cuts the axis of abscissæ at the point $\epsilon = 26\ \mu$ about. For thicknesses less than 50 μ the curve drops below the straight line. The function $\frac{1}{\rho}$ for thicknesses above 50 μ is of the form $-A + B\epsilon$. This implies the existence of a homogeneous layer which is comprised between two superficial layers of less conductivity at the contact of air and glass. As long as the intermediate homogeneous layer exists, the points in the diagram fall on the straight line. They depart from it when the total thickness of the layer becomes equal or inferior to the sum of the "thicknesses of passage." Hence the sum of the thicknesses of passage is about 50 μ, a value which is nearly that obtained by Quincke in his capillary experiments. Viewed under the microscope the layers used, even the thinnest, were

absolutely continuous. The equation of the straight line deduced from the mean of the results is

$$\frac{1}{\rho} = \frac{\epsilon - 26}{24{\cdot}2}.$$

The value deduced for the specific resistance at 0° of a sheet of silver sufficiently thick for the influence of the superficial layers to be neglected is 1·45 about; taking as unity Matthiessen's value for the specific resistance of ordinary annealed silver. J. J. S.

1251. *Resistance-box for Wheatstone-bridge Ratio-arms.* **O. Schöne.** (Zeitschr. Instrumentenk. 18. pp. 133–135, 1898.)—The author describes a new arrangement of resistances for the ratio-arms, enabling the resistances to be interchanged and their accuracy thereby tested. Eight brass pieces are fixed to two brass strips on the ebonite cover of the box, each piece being provided with two plug connections, one to each strip. These strips are the end terminals; the middle terminal is a third strip inside the box, between which and each brass piece are connected eight resistances, two each of 1, 10, 100, and 1000 ohms. Thus either of the 1-ohm coils, for instance, can be connected to either strip, and any ratio can be obtained in four different ways. Further advantages claimed for this arrangement are that only two plugs are required, whose contact-resistances, being always in circuit, can be allowed for in the adjustment of the coils; and that, by means of a third plug connecting two resistances in parallel, ratios of 1 : 5 and 1 : 20 may be obtained. G. H. Ba.

1252. *Condenser in Induction-coil.* **T. Mizuno.** (Phil. Mag. 45. pp. 447–454, 1898.)—The use of a condenser in the primary circuit of an induction-coil, in order to increase the efficiency (Fizeau) is well known but not well explained. There is a special amount of capacity required for each value of the primary current in order to make maximum secondary spark-lengths, and it is greater the stronger the primary current. On increasing the capacity the spark-length at first rapidly rises, then more slowly falls off. A. D.

1253. *Induction-coil Contact-breakers.* **M. Izarn.** (Journ. de Physique, 7. pp. 342–343, 1898.)—When the contact-breaker is not an independent one, the author finds that the results are more regular if the massive column is not rigidly but to a certain extent elastically fixed to the base-board. He mounts it on a strip of brass 6 cm. × 3 cm. × 1 mm., fixed to the base-board only at its two ends. The screw regulating the frequency must fit tight enough not to slip. A. D.

1254. *Improved Mercury Interrupter.* **H. Hauswaldt.** (Annal. Phys. Chem. 65. 2. pp. 479–480, 1898.)—The shape of the three-rayed star wheel used by Hofmeister is modified, as shown in the

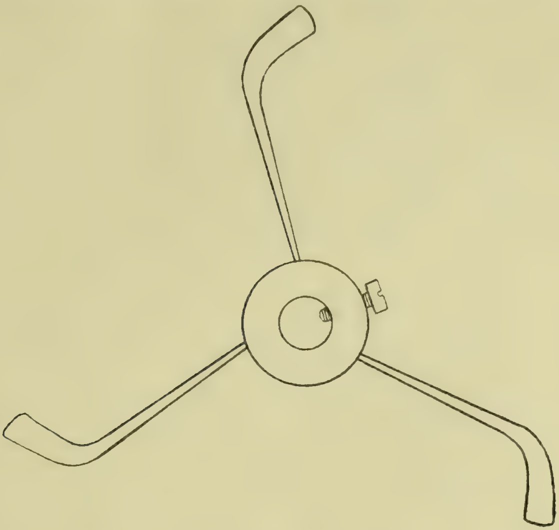


figure. The wheel is made of silver, with narrow blades, which enter and leave the mercury noiselessly. E. E. F.

1255. *Electrolytic Thermopiles.* **W. Duane.** (Annal. Phys. Chem. 65. 2. pp. 374–402, 1898.)—The author deals with thermopiles in which both electrodes are kept at the same temperature, and in which, consequently, the thermoelectric forces are developed in the electrolytes themselves. A second electrolyte is inserted between the two portions of the first which adjoin the electrodes, and the two liquid junctions are kept at different temperatures. The author used none but dilute solutions, so as to remain within the assumptions of Nernst's theory. In one set of experiments the two solutions were of the same electrolyte but of different concentrations; in the other they were of different electrolytes but of the same concentration. In both cases the results obtained were in close agreement with Nernst's theory, within the somewhat wide limits of experimental error. The middle solution was contained in a bulb with two arms bent downwards and dipping into the electrode solutions, the ends of the tubes turning up and being provided with small holes, through which the liquids came into contact. E. E. F.

1256. *Currents measured by Magnetisation.* **F. Pockels.** (Annal. Phys. Chem. 65. 2. pp. 458–475, 1898.)—The author endeavours to determine the maximum discharge-current by the remanent magnetism induced in magnetic substances acted upon by the current. Ballistic galvanometers only give the average intensity of a current, whereas the remanent magnetism would indicate the maximum current, whenever attained. To avoid eddy-currents, the author uses bars of basalt as the magnetic substance. The results are very favourable. A magnetic field lasting only about one-millionth of a second shows the same remanent (and probably also the same temporary) magnetisation as is induced by a field kept up indefinitely at the same strength. Hence the magnetisation of pieces of basalt may be used to determine the current strength of lightning discharges. E. E. F.

1257. *Magnetic Properties of Nickel-Steels.* **E. Dumont.** (Comptes Rendus, 126. pp. 741–744, 1898.)—The author has continued the work of C. E. Guillaume (Comptes Rendus, 124. p. 1515, 1897, and Phys. Soc. Abstracts, No. 517, 1897), and has examined the magnetic behaviour of nickel-steels, following the method of Prof. Ewing and Miss Klaasen (see 'Electrician,' May 15th, 1891). He has caused various alloys to traverse magnetic cycles, and has drawn curves showing the change of the permeability with change of the proportion of nickel, at various temperatures, and with various strengths of field. He finds that at an equal distance from the point of total loss of magnetism, all the reversible alloys have the same magnetic permeability. Moreover, at every temperature the permeability of alloys containing 27 to 44 per cent. of nickel increases with the proportion of nickel.

J. J. S.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

1258. *Change of Weight with Change of Temperature.* **P. R. Heyl.** (Frank. Instit. Journ. 145. pp. 385–387, 1898.)—The accepted explanation of the familiar fact that a hot body appears to weigh less on a balance than a cold one, is that the convection air-currents raise the scale. Certain experiments of Heyl having led him to suspect that there might be a true loss of weight in minute proportions, he has devised an apparatus (illustrated) to avoid convection. A sealed tube with a central constriction had, in the upper part, a short stick of potash, in the lower 50 °/₀ sulphuric acid. It was protected by a thin jacket containing solid acetic acid, and by an outer air-case. The whole was weighed, then inverted, whereby the potash and acid came in contact and internal heat was generated, then again weighed. No appreciable difference was recorded by the balance used. S. R.

1259. *Acetylene Compound with Cuprous Oxychloride.* **R. Chavastelon.** (Comptes Rendus, 127. pp. 68–69, 1898.)—The compound $C_2H_2 . Cu_2Cl_2$ is slowly decomposed into hydrochloric acid, acetylene, and a violet-coloured substance having the composition $C_2H_2 . Cu_2Cl_2 . Cu_2O$. The decomposition is incomplete in presence of hydrochloric acid. T. E.

1260. *Decomposition of Nitric Acid by Heat.* **M. Berthelot.** (Comptes Rendus, 127. pp. 83–88, 1898.)—As a preliminary to the investigation of the action of light on nitric acid, the decomposition of this substance by heat alone is studied. Pure nitric acid decomposes at 100° into oxygen, water, and nitric peroxide with absorption of a small amount of heat. The change is not reversible under the conditions in which the decomposition takes place. T. E.

1261. *Equilibrium in Mixtures of Water, Ether, and Succinonitrile.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 25. pp. 543–567, 1898.)—The results of a discussion of this system, which is such that *three* liquid layers may exist in equilibrium, are here given; a fuller account will follow later. But even the results here presented are too intricate to satisfactorily abstract. R. E. B.

1262. *Equilibrium of the System—Water, Benzoic Acid, Succinonitrile.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 26. pp. 237–254, 1898.)—In systems of three components different cases occur according to the behaviour of the components taken in pairs: (1) Each pair may form only homogeneous solutions; (2) two of the pairs may form only homogeneous solutions, while the third pair may form two liquid layers; (3) two pairs

may each form two liquid layers, the third pair alone forming only homogeneous solutions; (4) all three pairs may each form two liquid layers. The author has already experimentally investigated case (2) which occurs with sodium chloride, water, and succino-nitrile, of which the last two are the singular pair; and water, ether, and succino-nitrile (see Abstract, No. 1261) are an example of case (4); in the present paper an instance of case (3) is treated. But of case (3) there are two varieties: either (α) the layer-formation with both pairs may occur simultaneously, as with water, alcohol, and succino-nitrile (to which a later paper will be devoted); or (β) each pair may form its layers only at temperatures at which the other pair forms homogeneous solutions. The latter is the variety presented by the substances in this paper, water and the nitrile forming two liquid phases only at temperatures between 18°·5 and 56°·5 C., and the two liquid phases given by water and benzoic acid occurring only between 95° and 115°·5 C.; while benzoic acid and the nitrile form homogeneous solutions only. For details we must refer to the memoir itself. R. E. B.

1263. *Number of Nuclei in Supercooled Liquids.* **G. Tammann.** (Zeitschr. Phys. Chem. 25. pp. 441–479, 1898.)—Like the crystallisation-velocity, the number of nuclei spontaneously formed in a liquid varies with the degree of supercooling; the two factors completely determine the rate of solidification. The number is proportional to the volume of the liquid and the time of exposure, though in small volumes and times the proportionality is masked by the element of chance. The number is very sensitive to the purity of the sample and is altered in both directions by additions, soluble or insoluble; these do not, however, appreciably alter the position on the temperature curve of the maximum, which is very sharp, and lies in the region where the crystallisation-velocity falls off with reduced temperature. A large number of organic substances (59 out of 150 investigated, and fully described as to behaviour on solidifying) can be obtained as glass (liquids of high viscosity) by rapidly cooling to a temperature at which nuclei are no longer formed at an appreciable rate. Two or more polymorphic forms are frequently formed at the same temperature, and the number of nuclei of one can often be reduced apart from the others, by slight additions; the maximum for the more stable form often, but not always, lies at a lower temperature than that of the less stable form. A desired form might be obtained with greater certainty by sowing the liquid with a nucleus of this form at a temperature too low for the spontaneous appearance of nuclei.

The substances investigated quantitatively are piperidin and betol, and the method is to seal them in long capillary tubes, melt at a fixed temperature, and bring rapidly to the temperature of observation by plunging in a water-bath, and subsequently, where necessary, developing the nuclei formed at a temperature at which the velocity of crystallisation is appreciable, and that of nuclei-formation negligible. In some cases the tubes were first rapidly

cooled below the maximum of nuclei-formation, and then raised to the temperature of observation: the various methods showed by their agreement the reliability of the result. B. B. T.

1264. *Electrolytic Solution of Platinum and Gold.* **M. Margules.** (Annal. Phys. Chem. 65. 3. pp. 629–634, 1898.)—Platinum and gold may be dissolved without aqua regia by sending the current from an induction-coil through an electrolytic cell containing those metals as electrodes. A small U-tube is used as a cell, and in about three minutes the liquid about a platinum anode turns perceptibly yellow. In an hour, about 1 mgr. of platinum is dissolved. At least three Daniells must be used to feed the coil. Gold is similarly dissolved; but all its solutions are very sensitive to light. The yellow sulphate rapidly precipitates gold under the influence of daylight. The solution in caustic potash, whatever its nature may be, is somewhat more stable, and may be used for gilding. The author expects to be able to dissolve carbon in a similar way, and thus produce organic compounds. E. E. F.

1265. *Quantitative Electrolytic Separation of the Halogens.* **H. Specketer.** (Zeitschr. Elektrochem. 4. pp. 539–542, 1898.) —Electrolytic separations depending on regulation of the E.M.F. have hitherto been applied to the metals only; the principle is here made use of for the separation of chlorine, bromine, and iodine. Attempts to effect this by successive liberation of the free halogens from solutions of their hydrogen acids were unsuccessful; but satisfactory results are obtained by converting them into the silver halides by electrolysis of the potassium halides in normal sulphuric-acid solution between a silver anode and a platinum kathode. For the separation of iodine an E.M.F. of 0·13 volt should be employed, and for bromine 0·33 volt; the chloride remaining in the solution is best determined volumetrically by the usual methods. The silver salts are precipitated in a dense coherent form, easily washed, dried and weighed. During the electrolysis the oxygen of the air must be carefully excluded, otherwise erroneous results are obtained, and the solution is therefore placed in a narrow cylindrical vessel into which a current of hydrogen is passed. It is also most important that the concentration of the acid in the electrolytic cell and the E.M.F. employed should be maintained at a constant definite value, and that the anode should consist of perfectly pure silver wire. J. W.

1266. *Electrolytic Conductivity of Dilute Solutions at Temperatures up to* 100°. **R. Schaller.** (Zeitschr. Phys. Chem. 25. pp. 497–524, 1898.)—To avoid the solubility of glass at higher temperatures platinum apparatus is used. By placing this within a kind of diving-bell in a water-bath the temperature of the solution is maintained constant, and evaporation prevented. Small electrodes (platinised by means of a solution containing lead acetate) are used, since large ones give rise to considerable errors

owing to absorption of the dissolved substance. The author subsequently finds that vessels of normal Jena glass have little or no influence on the results obtained with solutions of salts or acids at 100°. The increase of the molecular conductivity of sodium and potassium chlorides and nitrates (1 molecule in 256 to 1024 litres) between 25° and 99° is nearly proportional to the temperature; the temperature coefficient increasing slightly with rising temperature, whilst for hydrochloric acid it diminishes. The sodium salts of a number of organic acids, examined under the same conditions, behave in the same way as the neutral salts above mentioned. Their temperature coefficients are practically the same (0·0264 to 0·0268 at 62°), and somewhat greater than those of the inorganic salts, in accordance with the rule that the electrolyte with the more mobile ions has the smaller temperature coefficient. Solutions of the free organic acids are only partially ionised, and in all cases the ionisation diminishes at the higher temperatures. In some cases this diminution is so large that the conductivity of the solution decreases at higher temperatures, notwithstanding the greater mobility of the ions. The heats of dissociation of all the acids examined diminish with rising temperature. T. E.

1267. *Sulphating of Negatives in Lead Accumulators.* **L. Jumau.** (Écl. Électr. 16. pp. 133–136, 1898.)—The evolution of hydrogen and formation of lead sulphate at the negative plates while the element is at rest is due to two principal causes—(1) the chemical action of the sulphuric acid upon spongy lead; (2) the electrochemical action of the couple formed by the spongy lead of the active material and the lead (often containing antimony) of the support. The accidental presence of particles of lead peroxide from the positives, or of copper from the connections, also favours sulphating, whilst the action is in all cases much increased by the use of acid of high density. The results of experiments are given showing the influence of acid-concentration and of time on the sulphating of charged plates at rest. In many cases the extent of the action is greater than can be attributed to the above-mentioned causes, and is found to be due to the presence in the active negative material of iron, and, more especially, of antimony. The latter is derived from the alloy of which the grids are composed, and is found almost entirely in the superficial layers of the active material. The experiments quoted show the great influence of small percentages (under 1 per cent.) of antimony upon the sulphating, especially in combination with acid of high density. It is recommended that soft lead, free from antimony, be employed for the positive plates, or, if this is impossible, that electrolytes of low density be used. It is often advisable to remove the superficial layers of spoilt negatives, notwithstanding the decreased capacity caused by this operation. J. W.

1268. *Comparative Cost of Ozone.* **J. B. C. Kershaw.** (Elect. Rev. 43. pp. 151–153, 1898.)—The writer gives, first, brief descriptions of each of the five following forms of ozoniser :— Andréoli, Otto, Yarnold, Siemens & Halske, Tindal & Van der Steen. Details of these have previously appeared in the Technical papers, and in the case of the Otto and Yarnold ozonisers have received notice in 'Science Abstracts' (see Nos. 190 & 426). The proposed applications of ozone are then enumerated, and these are submitted to a detailed examination as regards comparative costs of ozone and the oxidising agents at present in use for the purposes named. The two following tables give, in condensed form, the results of the writer's calculations :—

TABLE I.

Form of Ozoniser.	Yield of Ozone in grams per E.H.P. hour.	Cost of Electrical Energy in pence	
		per kg. Ozone.	per kg. Active Oxygen.
Yarnold	175	8·56	25·68
Otto	150	9·99	29·99
Andréoli	90	15·90	47·70
Siemens & Halske	20	75·00	225·00
Theoretical Figures	1000	1·50	4·50

TABLE II.

Comparative Costs of 1 kg. Active Oxygen

Source.	Cost in pence.
Bleaching Powder	18·3
Sodium Bichromate	48·0
Ozone. Yarnold's Ozoniser	61·5
Ozone. Otto's Ozoniser	66·0
Ozone. Andréoli's Ozoniser	83·7
Sodium Manganate. Acid Solution	86·0
Sodium Manganate. Alkaline Solution	153·0
Ozone. Siemens & Halske's Ozoniser	261·0

The writer holds that these figures prove

(1) That bleaching-powder is still the cheapest oxidising agent, and that for those purposes for which it is applicable and gives good results it will not be displaced by ozone.

(2) That ozone will be a keen rival to sodium bichromate and sodium manganate in the manufacture of oils, fats, and

organic products, and that in time it will probably displace these chemicals.

(3) That the extended application of ozone for producing results at present obtained by atmospheric influences—as, for instance, the purification of water, maturing of wines and spirits, etc.—is uncertain, and that further trials may result in failure due to economic and chemical causes.

AUTHOR.

1269. *Ozonisers.* **E. Andréoli.** (Électricien, 15. pp. 369–374, 1898.)—Andréoli's new ozonisers consist of plane aluminium plates and of aluminium plates built up of toothed ribbons, separated from one another by glass plates. Each plate has a total surface of 4 sq. ft. There are 17,760 points on the two surfaces of a ribbon-plate. Five of these point-plates and six plane plates are held by a wooden frame. The arrangement is vertical, and the ozoniser stands over the air inlet. Laboratory apparatus are put in glass cases; large batteries in rooms, whose walls are lined with glass or with enamelled bricks. The pointed-plate batteries are 30 per cent. more efficient than batteries containing only plane electrodes. A primary current of 2·45 amperes at 25 volts, and a secondary at 3000 volts, give good results. These currents do not produce much heat, nor do they cause oxidation of the nitrogen. The average yield is 125 g. of ozone per kilowatt-hour. The air arrives under pressure; further particulars about circulation are not given. H. B.

1270. *Electro-Deposition of Zinc.* **S. Cowper-Coles.** (Electrician, 41. pp. 382–383, 1898.)—The author of this short article gives the results of some experiments he has carried out in connection with the electro-deposition of zinc. A special cell was constructed with a revolving aluminium kathode, upon which zinc was electro-deposited from a zinc-sulphate solution, various gases being passed over the kathode during deposition, such as oxygen, air, carbon dioxide, coal-gas; the chief object of the experiments being to throw some light on the vexed question of the formation of zinc sponge. The best deposits were obtained with coal-gas and carbon dioxide. AUTHOR.

1271. *Electrolytic Refining of Lead.* **S. Cowper-Coles.** (Electrical Review, 42. pp. 779–780, 1898.)—The author reviews a number of processes that have been tried for the electrolytic refining of lead, and gives some details of the processes that have been worked by Keith, Tomassi, and Maxwell-Lyte. AUTHOR.

GENERAL ELECTRICAL ENGINEERING.

1272. *Practical Working of Accumulators.* **L. Gebhard.** (Zeitschr. Electrotechn. Wien, 16. pp. 261–265 & 277–280, 1898.)—After a brief historical introduction, the author deals with the improvements introduced during the past few years into the manufacture of the peroxide plates, the construction of the cell as a whole, and the management of cells. The gradual evolution of the modern type of Planté plate is fully considered, and its advantages over the pasted form of plate are pointed out. The application of modern accumulators capable of giving a high rate of discharge to electric traction is next considered; and the Hanover system is instanced as a successful example of what may be done in this direction. A. H.

1273. *Insulation and Conduction.* **R. A. Fessenden.** (Amer. Instit. Elect. Engin. 15. pp. 204–227, 1898.) Part II.—This is mostly a statement of facts and experience with regard to insulators. Rubber and ebonite are objectionable, because their surface becomes acid. It may be protected with paraffin. Glass is objectionable, because the alkali in it has a great affinity for moisture; also the angle of contact between water and glass is zero, and a drop of water spreads indefinitely. Quartz fibre is invaluable, because the water slides off. There is no reason why a suitable glass should not be designed. Porcelain with a non-alkaline glaze is excellent. For insulating coils paraffin is objectionable; its large coefficient of expansion strains the delicate wires. Rubber in contact with copper rots.

Manganin and constantan are unsatisfactory resistance-materials; pure lead run into glass tubes and kept in water has been adopted for standard resistances. Paraffin is best for condensers, and will stand 500,000 volts per inch.

Homogeneity in a dielectric is essential to volt-resistance. Thus, introducing a plate of glass into an air dielectric which is on the point of rupture under a high voltage alternating will precipitate that rupture.

The specific inductive capacity of oils may be reduced by expelling all the water. Silk should never be used in induction-coils where pure cotton can be had. The author considers that J. J. Thomson's discovery of the greatly increased dielectric strength of air with increased pressure should be used for cable-work. Thus air at 90 lbs. per sq. inch is equal to good rubber. Ice as a dielectric for cables is also suggested. Armatures may be insulated with asbestos string soaked in silicate of soda.

Insulation may be applied to cloth as a backing, but water creeps in at the edges and where the little tubes of cellulose protrude. Similarly with impregnated cloth (using, say, varnish dissolved in alcohol) the material in the tubes becomes filtered free of the gum, and will not be protected from water, which will be sucked up by

the tubes. For impregnation no substance may be used dissolved in another substance. Few substances which melt are elastic: there is a valuable exception, viz. imitate, commonly called gilsonite. It mixes with paraffin. Linseed oil has the advantage of expanding on drying, thereby filling the pores of any cellulose it may be used upon. No *lead* drier must be used with it, and for armatures pure raw oil is best. Time is gained by the employment of borate of manganese as a drier. The pure linseed oil is boiled at about 200° for several hours with $\frac{1}{2}$ % of borate of manganese till it begins to thicken. It always remains sticky.

A useful soldering-fluid is obtained by dissolving rosin in strong ammonia and using the soap as flux. An alarm against over-heating can be made by imbedding a spring and contact in carnauba wax. The wax remains solid up to the danger-point, and suddenly melts.

[For the first part of this paper, see Abstract No. 1249.]

M. O'G.

1274. *Chapman Pressure Regulator.* (Amer. Electn. 10. pp. 226, 227, 1898.)—This regulator comprises a series of resistance-coils to be inserted or removed from the field-magnet circuit of the generator to be regulated. These coils are connected to a series of copper segments placed in a horizontal row and having a contact-slider arranged to move over their surface. The contact-slider is operated by being mechanically connected to the moving core of the working solenoid, which consists of two differentially-wound coils placed on the ends of a horizontally arranged brass tube closed at each end. Inside the tube is fitted a soft iron plunger, to the centre portion of which is attached a rod passing out through a longitudinal slot in the middle part of the tube, and having the contact-slider secured to it. The motion of the plunger is damped by filling the spaces at the ends of the tube with oil and connecting these ends through a small pipe having a valve in it so as to regulate the flow of oil. The action of the differentially-wound coils on the iron core is controlled by a small auxiliary solenoid, which causes an arm to oscillate in one direction or the other and close the circuit of one or the other of the said coils. This auxiliary solenoid can be shunt-wound, "compound-wound" to regulate for constant potential at a distant point on the line, or series-wound for constant current. It will work to 1 per cent. with continuous currents and $\frac{1}{2}$ per cent. with alternating currents. It is made by the Belknap Motor Co., of Portland, Maine, U.S.A.

C. K. F.

1275. *Liquid Resistances.* **G. Dary.** (Électricien, 15. pp. 273–275, 1898.)—This paper discusses the advantages and disadvantages f liquid resistances with acid and alkaline electrolytes, and describes some experiments made in Baltimore, U.S.A., with a resistance consisting of two cylinders of galvanised iron mounted concentrically on a vertically-adjustable frame and cut off obliquely

towards their lower ends, so that the surface wetted increases gradually as the cylinders are immersed, the current passing from one to the other through the liquid. C. K. F.

1276. *Electric Revolution-Indicator.* **G. Dary.** (Électricien, 15. pp. 292–293, 1898.)—This indicator, devised by M. Cadiou, serves to indicate each revolution made by the propeller-shaft of a vessel and also the direction of rotation. For this purpose, it comprises a rod pivotally supported at or near its centre, and normally held with one end midway between two contacts by means of springs, the other end of the rod being provided with a roller adapted to be acted upon by a cam on the propeller-shaft. By these means, for each revolution of the shaft, the rod can be caused to touch one or other of the contacts and, by suitable connections with the lighting circuits of the vessel, to intermittently illuminate one or other of two incandescent lamps, according to the direction of rotation. By counting the number of times the particular lamp lights up in unit time, the speed of the shaft can be determined. When the intermittent illumination is transferred from one lamp to the other, it can be seen that the engines have been reversed. It has been found to work satisfactorily, during a six months' trial, up to 110 revolutions per minute, on board the 'Condor.' C. K. F.

1277. *Electric Heater.* (Amer. Electn. 10. pp. 228–229, 1898.) —In this heater the resistance-wire is looped backwards and forwards over alternating or "staggered" projections on circular porcelain blocks having square central holes and threaded onto a a square iron bar to prevent rotation, the wire extending round an arc of about 200° between each projection. A clear photograph of the core is given in the original paper. C. K. F.

1278. *Penmarch-Eckmuhl Electric Lighthouse.* **C. Du Riche Preller.** (Engineering, 65. pp. 551–552, 623–626, 1898.)—In this article the author describes, first, the site of the new lighthouse, the tower (which is 63 metres high), and the buildings adjacent thereto. The two engines for driving the dynamos and air-compressor are of the semi-portable Rouffet type, and each develop 12 effective H.P. They are provided with Monin's condenser, which consists of a system of metallic pipes surmounting the engines and permitting 75 % of the vaporised water being recovered (see 'Engineering,' July 7th, 1893, p. 10). The engines drive the two alternators, and the air-compressor by belting, and through the same countershaft. The air-compressor is of the Genty type, and supplies air through accumulators to a syren.

The alternators were designed by Prof. Blondel, and are made with two-phase winding so as to be capable of feeding two separate arc-lights in such a manner that the lighting or extinction of one light cannot affect the other. The alternators are each of 2·2 kilowatts, run at 810 to 820 revolutions per minute, have 8 poles, the

resistance of each circuit is 0·213 ohm, and the intensity of the field 4000 C.G.S. units. They are excited by small continuous-current machines whose armatures are wound on the alternator shafts. The main feature of the plant is the double optical apparatus, in which two complete arc lamps and optical systems are placed side by side. This was adopted since it has been found that, after a certain point is reached, the ratio of increase of luminous power in single apparatus is much smaller than the corresponding increase of electrical energy: thus a twin apparatus at 50 amperes in each lamp will be more economical, and will at the same time give more luminous power in the beam than a single apparatus at 100 amperes. The twin 4-panel apparatus of Penmarch has 6 dioptric and 10 catadioptric elements to each panel, with a focal length of 300 millimetres. The twin apparatus, weighing about 2 tons, is mounted on a platform revolving on the same shaft, to which is fixed a drum revolving in a mercury bath. On testing the apparatus, the following results were obtained:—

	Minimum Candles.	Maximum Candles.	Mean Candles.
10 mm. carbons	20×10^6	$26{\cdot}6 \times 10^6$	$23{\cdot}2 \times 10^6$
16 „ „	30×10^6	40×10^6	35×10^6

By comparison the luminous power of the La Hève single apparatus (see 'Engineering,' July 14th, 1893, p. 41) is as follows:—

	Minimum Candles.	Maximum Candles.	Mean Candles.
10 mm. carbons	9×10^6	12×10^6	$10{\cdot}5 \times 10^6$
16 „ „	$13{\cdot}5 \times 10^6$	18×10^6	$15{\cdot}75 \times 10^6$
23 „ „	$17{\cdot}25 \times 10^6$	23×10^6	$20{\cdot}15 \times 10^6$

Thus the compound beam of the twin apparatus, with 16 mm. carbons at 50 amperes in each arc, has a mean luminous power of 35×10^6 candles, whilst the La Hève single apparatus gives, with 23 mm. carbons at 100 amperes in single arc, a mean luminous power of $20{\cdot}15 \times 10^6$ candles, the ratio of increase being therefore 1 : 1·7.

Two 2-page plates of drawings of the lighthouse buildings and plant are given with the original paper. C. K. F.

1279. *Electric Capstans.* **E. Sartiaux.** (Écl. Électr. 15. pp. 459–469, 1898.)—This paper gives a description, with clear drawings, of electric capstans in use on La Compagnie du Chemin de Fer du Nord, and comprise (1) a capstan proper for haulage; (2) a direct-acting capstan for the rotation of turntables and swinging bridges; (3) a geared capstan for actuating a number of turntables or a hauling apparatus, as desired. In the first of these arrangements the hauling drum or head is mounted directly on the shaft of a series-wound 8-pole motor, mounted on a platform supported on trunnions in a cast-iron caldron-shaped base, so that it can be reversed for inspection or cleaning. The second arrangement is similar to the first, except that the motor-shaft is

provided with a sprocket-wheel driving the turntable or swinging-bridge through a driving-chain; the sprocket-wheel on the motor-shaft is connected thereto through a friction-clutch, the sections of which are held in engagement with each other by means of a spiral spring, this arrangement allowing the motor to stop gradually, even when the motion of the turntable or bridge is suddenly arrested. In the third arrangement the motor-shaft is provided at its upper end with a hauling-drum or head, and also with a gear-wheel which gears with three pinions capable of being connected to sprocket-wheels by means of friction-clutches operated by electro-magnets, the said sprocket-wheels driving turntables or swing-bridges through chains. The motors are driven from accumulators, a kilowatt-hour costing about 0·2 f. (1·9*d.*), the cost of each operation of a capstan varying between 0·004 and 0·005 f. The first type costs 5500 f. (£220), the second 6500 f. (£260), and the third 9000 f. (£360); this comprises the switches and conductors. The supply is at 100–110 volts, the normal current varies from 30–35 amperes for a pull on the cord of 400 kilos, and 70–75 amperes for 1000 kilos; the motor-shaft making 12–16 revs. per min. The descriptions are full, and are supplemented by a number of clear drawings and curves. C. K. F.

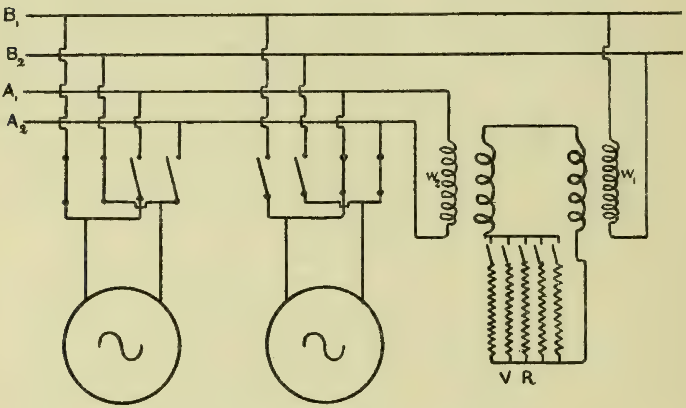
1280. *Electric Elevators.* **W. C. C. Hawtayne.** (Elect. Engin. 21. pp. 693–697, 1898.)—This paper, after briefly sketching the development of the electric elevator, gives full descriptions of several types of the Otis elevator, with starting, stopping, and safety devices, and also of the electric elevators made by Messrs. Waygood & Co., Messrs. Easton, Anderson & Goolden, and the Sprague Electric Company. C. K. F.

1281. *Communication between Railway-trains in Motion.* **J. Buse, Jr.** (Électricien, 15. pp. 293–295, 1898.)—The author describes briefly the systems of communicating between trains in motion devised by Alexandre Lefèvre (see 'Revue pratique de l'électricité,' 5th March, 1897), Messrs. Royse Bros. (see l'Électricien, 20th November, 1897, p. 336), and an American system described in l'Électricien, p. 71, 1st vol. 1898. C. K. F.

1282. *Combustion and High-Compression Motors.* **A. Witz.** (Comptes Rendus, 126. pp. 957–959, 1898.)—Explosion motors had almost caused combustion motors (Siemens, Brayton, Simons, Crowe, Foulis, Gardie, etc.) to be forgotten; but Diesel has recalled attention to their efficiency. The author refers to his paper in Ann. de Chim. et de Phys. vol. 30. 1883, in which Diesel's results were stated. The secret of Diesel's success is that he has secured high compressions; these being attained the classical cycle without modifications will provide equal efficiencies. A. D.

DYNAMOS, MOTORS, AND TRANSFORMERS.

1283. *Paralleling of Alternators.* **G. Frisch.** (Zeitschr. Elektrotechn. Wien, 16. pp. 227–228, 1898.)—Referring to Sahulka's article (see Abstract No. 861) on this subject, the author states that the method illustrated in the accompanying diagram has been in use at the Vienna central station since 1893, and has given very satisfactory results. B_1 and B_2 are the main bus-bars, while A_1 and A_2 are two auxiliary bars connected to rheostats forming an artificial load, and to the fine-wire winding W_2 of



a synchronising transformer whose other winding may be connected, through a variable resistance VR, to the secondary of another transformer whose primary winding W_1 is across the main bus-bars. The alternator having been run up to full speed, it is connected across the auxiliary bars, and is then, by suitably adjusting the artificial load and exciting current, brought into approximate equality of phase and P.D. with the mains (the usual lamp-signal method being employed for this purpose). The secondaries of the synchronising transformers are then closed, and the resistance between them reduced step by step, the incoming machine being thereby brought into perfect phase-relation with the mains. The output of the synchronising transformers need not exceed $2\frac{1}{2}$ % of the alternator output. A. H.

1284. *Single-Phase Alternating Current Motors.* **E. C. Hoadley.** (Elect. Rev. 43. pp. 66–68, 1898.)—This is an article on the performance of the single-phase motors working on the Worcester supply mains. The maximum load on the station is 330 kilowatts, and of this 120 kilowatts are supplied by means of water-power, the remainder being accomplished by steam. The

current is generated at 2000 volts at a frequency of 100 cycles per second, and is distributed at 100 volts. The motors driven from the station aggregate 100 H.P.: of these some are synchronous and some induction motors made by the Oerlikon Company and the Langdon-Davies Motor Company. Little difficulty is experienced in the regulation of the plant unless a motor is suddenly switched on during a period of light station-load. During periods of light load it is found profitable to supply current for motive power at $1\frac{1}{2}d.$ per unit. When motors are run during periods of heavy load the charges are as follows:—

Not exceeding 1000 units per quarter, $3d.$ per unit.
Over 1000, not exceeding 2000 units per quarter, $2\frac{1}{2}d.$ per unit.
Over 2000, not exceeding 5000 units per quarter, $2d.$ per unit.
Over 5000 units per quarter, $1\frac{1}{2}d.$ per unit.

And for motors which do not use as many units as a one-hour's daily use of their maximum demand, $6d.$ per unit.

The power-factor of the Worcester plant varies from 0·5, when the load is light and composed chiefly of motors, to 0·98, when the load is chiefly incandescent lamps. The efficiencies of the motors vary from 75 to 84 per cent. according to their sizes. If the load of an alternating-current station consists partly of motors, the alternators should have no iron in their armatures, otherwise there will be considerable variation in the lights on switching on motors. W. G. R.

1285. *Induction Motors with Large Starting Torque.* **M. Déri.** (Zeitschr. Elektrotechn. Wien, 16. pp. 285–290, 1898.)—After a brief sketch of the theory of induction-motors, the author explains a neat graphical method of obtaining the torque-speed curve of such motors. He then proceeds to consider the one weak point of high-efficiency induction-motors, viz. their small starting torque. In starting against a load it becomes necessary to introduce resistances into the armature circuit; these are gradually cut out as the motor gains speed. The usual methods of accomplishing this result cannot be considered quite satisfactory, as they involve considerable complications. The author has solved the problem in an exceedingly ingenious manner. Briefly stated, the method consists in halving the number of poles in the motor-field at starting, and when the motor has run up to about its normal speed, changing the field-connections (by a single movement of a suitable switch) so as to produce the normal number of poles. To explain the principle of his method, the author considers the simple case of a 4-pole polyphase motor. Fig. 1 represents a group of 4 conductors forming one element of the induced winding. It will be readily seen that if such a winding is subjected to the inductive action of a 2-pole field, there will be no resultant E.M.F. in any position. Let now a cross-connection be introduced, as in fig. 2. The effect of this is to transform the group of 4 conductors into what is practically a single closed loop consisting of 2 parallel branches. With a

2-pole field, currents will now appear in the conductors, and a torque will be produced. By making the cross-connection of sufficiently high resistance, the starting torque may be made very large. When the motor has run up to speed, the field-connections are altered so

Fig. 1.

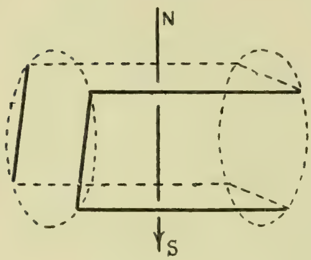


Fig. 2.

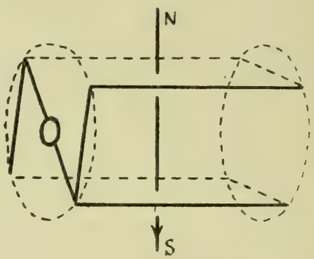
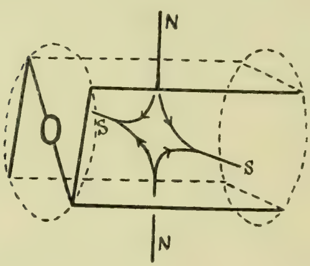


Fig. 3.

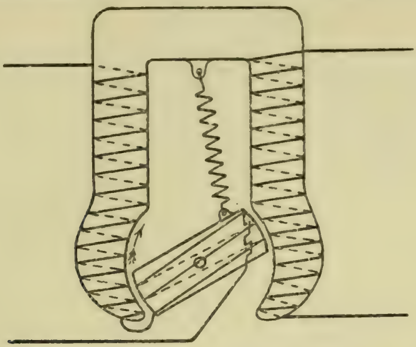


as to produce a 4-pole field, as in fig. 3. The effect of this change is to alter the parallel arrangement of the conductors to a series one, and to *completely arrest the current in the cross-connector.* The latter, in fact, takes no part in the action of the motor when running under normal conditions. The advantages claimed by the author for this method are: a simple form of induced winding, requiring no high insulation, and the entire absence of collecting-rings, rheostats, and multiple-contact starting switches.—The principle of the method is equally applicable to single-phase induction motors; but the arrangements are then more complicated, a commutator and brushes being required at starting. The author describes two different designs for a 4-pole single-phase motor.

A. H.

1286. *Transformer with Variable Ratio of Transformation.* (Elekt. Runds. 15. pp. 177–178, 1898.)—The object of this device, recently patented by A. Nicolaysen, is to secure constancy of

secondary P.D. with variable secondary current, thus compensating (in an automatic manner) for the drop in the transformer itself and



the mains connected to it. The mode of action will be evident from the subjoined sketch. A. H.

1287. *Regulating Transformers.* **G. W. Meyer.** (Elekt. Runds. 15. pp. 192–195, 1898.)—The author briefly refers to the various devices, such as those due to Stillwell and Kapp, for maintaining a constant P.D. at the feeding-points of alternate-current networks. He then describes an arrangement of his own, which mainly differs from those hitherto proposed in that the secondary of the regulating transformer is connected across the feeding-points and not in series with the feeders. The device is illustrated in fig. 1. It will be seen that two auxiliary mains are required, of

Fig. 1.

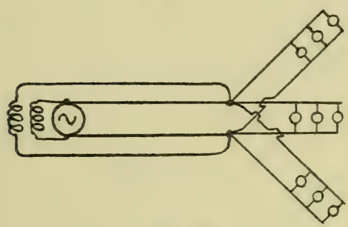


Fig. 2.

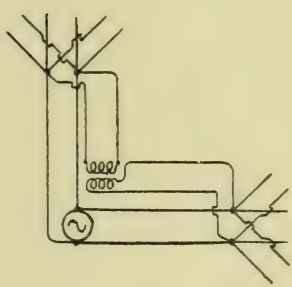
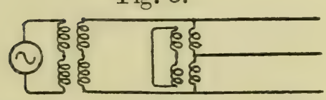


Fig. 3.



sufficient cross section to carry the maximum "equalising" current. Fig. 2 shows an application of the same principle to the problem of maintaining equality of P.D. between any two feeding-points of a network; while fig. 3 shows how such an "equalising" transformer may be applied to a 3-wire network. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1288. 200-*Volt and Alternating Current Systems.* **G. D. Shepardson.** (Amer. Electn. 10. pp. 249–251, 1898.)—The first part of this article deals with the saving of copper in the line when high voltages are used for transmission of electrical energy. The following table is arrived at by calculation :—

Wire for delivering 10,000 *watts* 1000 *feet at* 10 *per cent. loss.*

Volts delivered.	Size Wire.	Weight of Wire, in lbs.	
		Bare.	Weatherproof.
100	0000	1240	1460
110	000	1014	1176
120	00	804	952
220	4	252	320
1100	18	10	22
1100	10	63	102

The second part is a comparison between the 220- and the 110-volt system. Forty-six arguments are advanced in favour of the 220-volt system and twenty-nine against it ; but, as the author says, many of them are matters of opinion and depend often upon the quality of work turned out by manufacturers of lamps, etc. The author advocates the use of alternating-current high-tension systems where the distance from the generating station to the centre of distribution is appreciable. For a plant with 60-kilowatt machine about 3600 feet from the centre of distribution, the tender for alternating-current system was $5100, while that for 220-volt was $5742 with belted generator, and $6242 with direct-connected generator. W. G. R.

1289. *Prevention of Interruptions to Electricity Supply.* **L. Andrews.** (Instit. Elect. Engin. Journ. 27. pp. 487–523, 1898.)—The author of this paper contends that the indiscriminate use of fusible cut-outs is almost entirely responsible for the still existing popular belief that electricity supply is unreliable. Whilst admitting that a certain number of safety devices are necessary, he considers that these, and all other mechanical connections in an electric circuit, should be reduced to a minimum. Particular attention is drawn to the uselessness of fuses between primary or secondary generators and the bus-bars they supply, since it almost invariably happens that when a generator does fail the fuses of the healthy generators are blown before those of the faulty one. It is recommended that these fuses should be replaced by discriminating cut-outs—that is to say, by cut-outs that will not be operated by

any amount of current supplied from the generator to the bus-bars, but that will disconnect a failing generator from the rest of the system immediately it attempts to rob current from the other generators. Cut-outs that have been designed especially for this purpose are illustrated and described. It is shown that these special cut-outs are able to discriminate between a generator and a motor current, even when used for alternate-current work, in spite of the fact that the direction of the current in this case is normally constantly being reversed. Great attention has been paid to the mechanical details of these cut-outs, to ensure absolute reliability. It is shown that no amount of mechanical vibration can possibly cause them to operate; on the other hand, a very small motor current will do so.

A novel system of Electricity Distribution is also described. This consists of a number of substations or feeding-points connected together in such a manner that each point is fed by two or more feeders. Discriminating cut-outs are inserted in series with each feeder at the substation end, and these, in conjunction with fuses at the generating-station end, operate to automatically disconnect any feeder in the event of its becoming short-circuited. It is shown to be possible by this arrangement to short-circuit any feeder at any point without interrupting the supply to any lights.

AUTHOR

1290. *Halifax Electric Tramway.* (Electrician, 41. pp. 349–354, 1898.)—An illustrated account is given of this municipal system, where the traction plant has been combined with a 2000-volt alternating-current lighting system. A 120 kw. tramway generator is rope-coupled to a 100 kw. E.C.C. alternator as a motor generator. Running off the cells it can supply the day lighting-load, or off the alternating bus-bars as a synchronous motor it can supply the tramway. Separate cells are used for exciting purposes. The tramway battery contains 270 63-plate chloride cells, and has a capacity of 200 amperes for six hours. There are now ten 44-passenger cars running over four miles of track, mostly on a gradient of 1 in 18. Besides hand-brakes and electric brakes, there is a pair of slipper brakes consisting of wood blocks which are forced down on to the rails between the leading and trailing wheels. The Electric Light Committee provide plant and lay feeders, charging the Tramways Committee 2*d*. per unit for power, this charge including interest and sinking-fund. E. H. C.-H.

1291. *Paris Electric Tramways.* **R. T. Collins.** (Elect. Engin. 21. pp. 486–488, 1898.)—This article forms part of a contribution to the *Contract Journal.* The author gives an account of the line working on the accumulator and mixed systems. Also of the line from the Place de la République to Roumainville, working on the Claret Vuilleumier surface-contact system. The article concludes with a comparison of the cost of steam and electric tramway traction. W. R. C.

1292. *Earth Returns for Electric Tramways.* **H. F. Parshall.** (Instit. Elect. Engin. Journ. 27. pp. 440–456, 1898.)—A series of tests were undertaken in order to determine the conductance of the return system of electric tramways, consisting of rails laid on a concrete bed in the usual way, and in order to locate definitely the different elements of resistance. The following is a summary of the tests :—

(1) Specific resistance of a steel rail and its variation with chemical composition.
(2) Determination of the resistance of the joints.
(3) Determination of the relative conductivity of the track-rails and the earth.

Referring to No. 1, namely, specific resistance of steel rails, a table is given which shows the variation of resistance with chemical composition. Generally speaking, resistance varies with the amount of carbon and manganese. The resistance of steel rails, as manufactured at the present time in England, is about eleven times that of copper at 20° C., the following being the chemical composition :—

Carbon	·4	to	·5
Manganese	·95	„	·85
Silicon	·1	„	·06
Phosphorus	·1	„	·08
Sulphur	·08		

Referring to No. 2, *i. e.* determination of the resistance of the joints, the resistance of the rail-joints is made up of the resistance due to the gathering of the current towards points of contact of bond and fishplate, together with the resistance of contact of the fishplate and bond. Taking a 76-lb. rail as an example, with a fishplate 20″ long, and using Chicago bonds of No. 0000 copper, the following is a statement of various elements of conductance in the joints :—

	Resistance per joint.	Conductance per joint.
Fishplates alone	·0000826	12100
One 30″ Chicago bond. 0000 B. & S. alone	·000103	9700
Two 30″ Chicago bonds. 0000 B. & S.	·0000515	19400
Fishplates and one bond	·000046	21800
Fishplates and two bonds	·0000317	31500

Roughly, the resistance per mile of a 76-lb. rail, made up of 30′ lengths, is as follows :—

Resistance per mile of 76-lb. rail,	=	·0615
With fishplates and without bonds,	=	·076
With fishplates and one bond, as above,	=	·0696
With fishplates and two bonds, as above,	=	·0671

The efficiency of the different bonds was also determined, and a table given showing a comparison between Chicago bonds, Crown

bonds, Columbia bonds, and Plastic bonds. The relative efficiency of different methods of jointing the rails is also discussed; and the electric welding of joints and the cast weld joint is compared with an ordinary fishplate joint.

Referring to No. 3, *i.e.* determination of the relative conductivity of the track-rails and the earth, tests were made by means of the potentiometer method, and also by inserting an ammeter in the rails at different sections on the line, to determine the amount of stray current at different distances from the source of supply. Generally speaking, it is found that a third of the whole current put into the rail at one end strayed into the earth, returning again into the rail and concentrating towards the point at which the current was drawn out of the rail, so that the voltage drop measured between the near and distant ends of the rails was only about two-thirds of what it would have been had the currents been wholly in the rail. The influence of this upon electrolysis of water-pipes and gas-pipes is discussed. It was also proved that the conductivity of the earth is so large compared with the conductivity of a system of water-pipes and gas-pipes in the earth, that the pipes themselves take but a small proportion of the total stray currents.

AUTHOR.

1293. *Rail Bonding.* **H. C. Chase.** (Street Rly. Journ. 14. p. 224, 1898.)—This paper is an abstract of one read before the Texas Street Railway Association. The author draws attention to the great waste of electric energy caused by imperfect bonding. The Houston Electric Street Railway Company has obtained good results with No. 0 tinned copper wire and 19-32 in. channel-pins.

W. R. C.

1294. *Life of Sleepers.* **D. D. Willis.** (Street Rly. Journ. 14. pp. 225–226, 1898.)—This is an abstract of a paper read before the Texas Street Railway Association. At San Antonio cedar sleepers have been found in perfect condition after 20 years. In a moist climate cypress lasts as well as cedar, but in a dry climate they are no better than sap-pine. Heart-pine lasts from 5 to 8 years, cedar from 25 to 30 years. Heart-pine would probably last well if treated with carbolinum (or C.A. wood-preserver). The author's experience relates to such conditions as are found in Texas.

W. R. C.

1295. *Oscillation of Cars.* **J. H. Brill.** (Street Rly. Journ. 14. p. 226, 1898.)—The author discusses the oscillation of cars, and opposes the theory put forward by a previous writer in the 'Street Railway Journal' (see Abstract No. 721). Soft journal-springs should be avoided, thus diminishing the oscillation by causing the body to oscillate upon the longer base provided by the body-springs.

W. R. C.

1296. *Patton Motor Tram-Car.* (Street Rly. Journ. 14. p. 226, 1898.)—Figures are given relating to the test of a Patton car, which was run 274·1 miles on the Great Western Railway (U.S.A.). The time taken in running this distance, omitting stops, was 16 hrs. $45\frac{1}{4}$ min. Taking gasoline at 5 cents ($2\frac{1}{2}d.$) per gallon, the cost of fuel amounted to $1\frac{1}{17}$ cent (0·53*d.*) per car mile, or $0·00064 (0·032*d.*) per ton mile. W. R. C.

1297. *Tram-car for Mixed Traction.* (Railway World, 7. p. 85, 1898.)—Brief description of the new cars used in Paris. They are carried on Brill bogie-trucks, so constructed that 80 % of the weight is supported by the two driving-wheels. W. R. C.

1298. *Elieson-Naylor Controller.* (Elect. Rev. 43. pp. 149–150, 1898.)—Simplicity, ease, and reliability of contact are claimed for this controller, which is intended for any electrically propelled vehicle. By the addition of an auxiliary switch operated by depressing the controller handle, the circuit can be made or broken at any moment, thus reducing the time necessary to start or stop the vehicle. A simple foot-switch is also illustrated, intended for reversing the motor or for an electric brake. E. H. C.-H.

1299. *Electric Lighting of Edinburgh.* **F. A. Newington.** (Elect. Engin. 22. pp. 41–43, 1898.)—This is a paper read before the Incorporated Association of Municipal and County Engineers at Edinburgh. The Edinburgh Electric plant is capable of supplying 2680 kilowatts direct current and 468 kilowatts alternating current. The following details of the financial results are of interest:—

Price per Unit.

1895–6	Lighting 6*d.* per unit.	Power $3\frac{1}{2}d.$ per unit.
1896–7	,, 5*d.* ,,	,, 3*d.* ,,
1897–8	,, 4*d.* ,,	,, 2*d.* ,,
1898–9	,, $3\frac{1}{2}d.$,,	,, $1\frac{1}{2}d.$,,

Units sold each year.

	1895–6.	1896–7.	1897–8.
Private lighting	556,744	1,052,570	1,973,315
Power......................	13,914	47,727	86,654
Public lighting	331,043	621,276	834,660
Total	901,701	1,721,573	2,894,629

Capital expenditure, £282,000.

Year.	Net Profit.
1895–6	£3976
1896–7	£3374
1897–8	£2000 to £3000 (estimated).

W. G. R.

TELEGRAPHY AND TELEPHONY.

1300. *Selector System of Circuits.* **J. Voisenat.** (Écl. Électr. 15. pp. 393–400, 1898.)—This is a system for operating any one of a series of local circuits on a single line, independently of the others. Each local circuit is controlled by a rotary electromagnetic switch, designed to rotate by steps as dots and dashes are received from line. To each switch corresponds a certain sequence of dots and dashes; if this particular sequence is "received," the switch actuates the local circuit; but for any other sequence the switch has no effect on the local circuit. The sending arrangement on the line-circuit is "automatic;" the sequences of dots and dashes are represented by teeth in the edges of rotating discs, any one of which can be brought into play, according to the particular local circuit to be operated. As a matter of detail, there are two discs on the "sending" apparatus, corresponding to each local circuit; so that positive and negative signals take the place of dots and dashes. R. A.

1301. *Hertzian Telegraphy: Receiver.* **E. Ducretet.** (Comptes Rendus, 126. pp. 1266–1268, 1898.)—Description, with drawing, of apparatus made to act automatically, unrolling the paper when the waves come and stopping when the signalling ceases, and recording the message in longs and shorts. A. D.

1302. *Hertzian Telegraphy.* **G. Goisot.** (Écl. Électr. 15. pp. 370–371, 1898.)—A sketch of the early work done by Popoff in this department. A. D.

1303. *Telephone Exchange at St. Louis.* **F. E. Bausch.** (Elect. Engin. N. Y. 25. pp. 417–424, 1898.)—Describes the new system of the Bell Telephone Co. of Missouri. Underground cables have been substituted for overhead wires. The Western Electric Co.'s common battery system replaces the Law system of communication previously in use. The equipment of the switchboard is for 4000 subscribers. The article describes in detail the various features of a modern telephone exchange. J. E. K.

1304. *Telephone Exchange Lines.* **P. Heina.** (Écl. Élect. 15. pp. 103–107, 1898.)—When the overhead wires of a telephone exchange system become congested, the further increase is usually best met by running cables to distributing points, whence the subscribers are reached by short overhead wires. The resulting lines are longer than on a direct course, and a formula is suggested for determining the frequency of distributing points so as to limit the increase in the line distance. An illustration of the method is given as applied to the town of Marseilles. J. E. K.

1305. *Temporary Switchboard.* (Elect. World, 31. p. 468, 1898.)—The equipment is described of the new Exchange known as the John Street Exchange recently opened in New York. Pending erection of the permanent multiple switchboard of the Common Battery type, the Exchange has been fitted with a board of the divided type. Each operator has before her only the jacks and drops of her own subscribers, and is not, as in the Multiple boards, within reach of the spring jacks of all the subscribers on the board. The subscribers are multipled on the Trunk boards. An answering operator asks for a trunk line, and connection is completed by the trunk operator. On completion of the permanent plant this temporary switchboard will be retained as an Emergency board in any exchange where it may be necessary to provide quickly a new equipment. J. E. K.

1306. *Inductance in Telephony.* **W. Moon.** (Elect. Rev. 42. pp. 502–504, 539–540, 1898.)—The author describes a method of measuring self and mutual inductance for telephonic currents, and gives a list of inductances for standard telephonic apparatus, with formula for calculating the impedance when the resistance and inductance of a circuit are known. The induction-coils used with telephones are not of the closed magnetic circuit type. The primary current of a telephone induction-coil is undulatory but not alternating, so that the inductances of such coils are single-current inductances, and it is necessary to use coils with broken magnetic circuits having but little residual magnetism. The sheathing of indicators and transformers acts in every way similar to a short-circuited secondary circuit. The cores of electromagnets act as secondary circuits in the same way as an iron sheathing, and for this reason telephonic induction-coils are provided with cores of iron wires oxidised on the surface. A more efficient core can be made by winding iron-foil up in a coil with paper between each turn. A transformer can be similarly made. Apart from a better insulation, more iron can be got in the same space.

J. E. K.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

DECEMBER 1898.

GENERAL PHYSICS.

1307. *Surface-Tension and Electrostatic Induction.* **S. J. Barnett.** (Phys. Rev. 6. pp. 257–284, 1898.)—To determine the surface-tension, the method of ripples is employed. Above the liquid is placed a conducting-plate, an air-condenser being thus formed. Electrification diminishes the apparent surface-tension, the diminution being *independent* of the sign. The relative diminution is greater with water than with mercury. A. Gs.

1308. *Viscosity of Insulating Liquids.* **W. Schaufelberger.** (Annal. Phys. Chem. 65. 3. pp. 635–640, 1898.)—This is a criticism of Quincke's work on viscosity of liquids in a constant electric field. König failed to observe any increase of viscosity in capillary tubes subjected to an electric field. The author explains the increased damping of Quincke's weights suspended in a liquid, by the consumption of energy in the variation of the charges of the weights, the liquid, and the walls of the vessel. E. E. F.

1309. *Tensile Strength.* **W. Voigt** and **L. Januszkiewicz.** (Göttingen Nachrichten, 1. pp. 107–112, 1898.)—In this paper the authors show that the tensile strength of a substance depends on the *difference* between the longitudinal and transverse tensile stress. This is proved by some experiments on a mixture consisting of 61·5 p. c. of stearic acid, 22·0 p. c. of palmitic acid, and 16·5 p. c. of German paraffin (melting-point 74°–80°). Rods of the mixture are broken under tension in the air, the pressure at right angles to the pull due to the atmosphere being 10 grammes per sq. mm.; the applied tensile stress per square mm. equals

$145 \pm 1{\cdot}9$. Rods are also broken in a vessel containing air at a pressure of 413 grammes per sq. mm.; the applied tensile stress per unit area equals $146 \pm 2{\cdot}5$. The applied stresses are thus practically the same in each case.

The results may be expressed in another form. Let P equal the longitudinal, and D the transverse pressure, in grammes per sq. mm. Then

In air	$P = -135$,	$D = +10$.
In the vessel	$P = +267$,	$D = +413$.

It will be observed that the mixture breaks with a *tensile* fracture when subjected to a longitudinal *pressure*.

Besides the above there is a reference to some experiments of a kindred nature on rock-salt. A. Gs.

1310. *Pendulum Make and Break.* **C. T. Knipp.** (Amer. Journ. Sci. 5. pp. 283–284, 1898.)—A T-shaped frame of thin sheet-brass is pivoted at its centre to the pendulum-rod; in the lower end of the stem is a slot which engages a stud on the pendulum. The arms of the T end in platinum tips. Underneath these are flat steel springs, easily adjusted by means of set screws and resting on binding-posts. The circuit is closed when the pendulum passes through its lowest point. The circuit comprises a sounder. H. B.

1311. *Tidal Wave in Rivers.* **Partiot.** (Comptes Rendus, 126. pp. 1613–1615, 1898.)—The author explains a method of plotting tidal graphs for different stations on a river by means of observations taken at one of the stations, A suppose. It is necessary to assume some law of velocity of propagation for elementary waves supposed to start from A. The author tried five different formulæ, and compared the results with actual observations made on the Gironde and the Garonne. Boussinesq's formula,

$$\omega = \sqrt{g\mathrm{H}}(1+3k'/4\mathrm{H}),$$

appeared to be the best of the five. G. B. M.

1312. *Vaporisation of Thin Wires.* **M. Toepler.** (Annal. Phys. Chem. 65. 4. pp. 873–876, 1898.)—When a thin wire is vaporised by a strong electric discharge its vapour arranges itself in strata, as may be shown under favourable circumstances by depositing the vapour upon glass. A battery of condensers is fed by a 60-plate Toepler machine. It has two discharge-circuits in parallel, each provided with a spark-gap. The circuit containing the smaller spark-gap also contains the wire to be vaporised. The gaps are so adjusted that when the condensers are disconnected the discharge only passes through the circuit containing the thin

wire. Then, on inserting the condenser, the discharge passes through both gaps on account of the sudden increase of resistance in the one containing the disintegrated wire. In this manner a single oscillation only passes through the thin wire, and a clear stratification is obtained. A glass plate is placed a few millim. below the wire, and after the discharge has passed a clearly stratified deposit, with a distance of one or two millim. between the strata, is obtained on the glass. When two glass plates are used, one above and the other below the wire, two stratified deposits, with exactly similar intervals, are obtained. The best results were obtained with a silver wire 10 cm. long and 0·012 cm. thick, a sparking-distance of 1·5 cm., an initial difference of potential of about 35,000 volts, and a capacity of about 0·25 microfarads in the condensers. The deposits obtained show that the vapour was stratified in lenticular masses, resembling the stratification in a vacuum-tube. Microscopically, the deposit resembles a fine sublimate. E. E. F.

1313. *Stability of Equilibrium.* **L. Lécornu.** (Comptes Rendus, 126. pp. 1777–1778, 1898.)—Let a material particle be acted upon by a force, not derivable from a potential, whose components parallel to rectangular arcs are linear homogeneous functions of x, y, z. Then the necessary and sufficient conditions for stable equilibrium at O are that there are three real lines through O at any point of which the force is directed towards O. These three lines are not orthogonal.

The introduction of a geometrical constraint may destroy stability. G. B. M.

LIGHT.

1314. *Refraction and Temperature.* **J. O. Reed.** (Annal. Phys. Chem. 65. 4. pp. 707–744, 1898.)—The refractive indices examined are those of fluorspar, quartz, calcspar, and a large number of glasses. The prisms are provided with an additional surface, giving a reflected image of the slit side by side with the spectrum. Any change of refractivity is then indicated by a relative shifting of the slit and the spectrum-lines. The dispersion is increased by heat in every case, even when the refractivity decreases. The latter happens in fluorspar, quartz, and in glasses after the softening temperature is reached. Before that temperature there is an increase of refractivity with temperature. In calcspar the refraction of the ordinary ray is only slightly affected by heat, but that of the extraordinary ray is considerably increased. Quartz shows a strong decrease of the refractive index, which becomes more accentuated at the higher temperatures. E. E. F.

1315. *Dispersion of Sylvine, and Metallic Reflection.* **A. Trowbridge.** (Annal. Phys. Chem. 65. 3. pp. 595–620, 1898.)—The author investigates the reflective powers of gold, copper, brass, iron, nickel, and speculum metal as compared with that of silver between $\lambda=1\,\mu$ and $\lambda=15\,\mu$. For the shorter wave-lengths he uses a fluorspar prism; for the longer ones two sylvine prisms in succession, since sylvine does not absorb the longer waves to the same extent as fluorspar. The refractive index of sylvine, as determined with the radiometer, varies from 1·480 for $\lambda=0{\cdot}982\,\mu$ to 1·452 for $\lambda=11{\cdot}197\,\mu$. The reflective powers of the metals mentioned are tabulated in detail. The magnetic metals show minima at about $\lambda=9\,\mu$, probably owing to a peculiarity of the magnetic susceptibility at those points. E. E. F.

1316. *Microscopic Images and Vision.* **L. Wright.** (Phil. Mag. 45. pp. 480–503, 1898.)—The author raises objections to Dr. Stoney's presentation of the theory of microscopic vision (Phil. Mag. 1896), and proceeds to consider how far the Abbé theory furnishes an adequate explanation of the facts. He is of opinion that "the trustworthiness of a microscopic image is in proportion as the object approximates to a self-luminous condition, and diminishes in proportion as it is, or has to be, examined by plane-wave illumination." T. P.

1317. *Theories of Microscopic Vision.* **G. J. Stoney.** (Phil. Mag. 46. pp. 156–162, 1898.)—L. Wright has published a criticism [see Abstract No. 1316] chiefly directed against a resolution of light

into uniform plane wavelets which had been employed by the author in investigating the phenomena of microscopic vision. The present paper points out that Mr. Wright had formed an erroneous conception of this method of resolution, and endeavours to give such a description of it as can be understood by readers who are not experts in mathematical physics. This description may be summarised as follows :—

What the author had proved is that the system of waves propagated from a luminous punctum (or physical point) through a uniform transparent medium, may be resolved into the coexistence of innumerable uniform plane wavelets—wavelet meaning a wave of infinitesimal intensity. The luminous punctum may be either a self-luminous source of light, or one which becomes a source of light only when incident light falls on it; and the medium may be either isotropic (in which case the waves to be resolved are spherical) or double-refracting (in which case they have the form of the wave-surface in crystalline media).

Light really consists of electromagnetic waves; but that useful branch of Optics called Geometrical Optics is built upon an hypothesis, in which a more easily manipulated machinery is substituted for the waves. In Geometrical Optics the light is treated as if it consisted of "rays of light" subject to the laws of reflection, refraction, etc., and which, where they converge, produce an illumination equal to the sum of their separate illuminations. This hypothesis is legitimate, because it yields by an easy process valuable results; since it can be proved that the images which it furnishes are correctly situated and are in other respects a useful approximation to the images produced by the waves which are what really exist in nature.

Now the new resolution into plane wavelets may be perhaps most easily conceived by first picturing the "rays" of Geometrical Optics diverging from the punctum, and by then substituting for *each* of these rays a train of plane wavelets advancing in the direction of the ray, and with their fronts perpendicular to the ray if the medium be isotropic or oblique to it in double-refracting media. The plane wavelets are, in fact, in all cases tangential to the wave-surface in the medium; and the rays of Geometrical Optics are in reality not rays "of light," but mere geometrical lines from the source of light to the points of contact between the plane wavelets and the wave-surface. AUTHOR.

1318. *Study of "Flicker."* **T. C. Porter.** (Roy. Soc. Proc. 63. pp. 347–356, 1898.)—In the first part of the paper the author describes experiments made to ascertain the exact relative rotations at which the flicker of a disc, half black, half coloured, vanishes in the different colours of the spectra of sun- and lime-light formed by a diffraction-grating of 14,434 lines to the inch. The results may be summed up as follows:—The rate of rotation of the disc that the flicker may just vanish is highest for the yellow, decreasing

for the succession of colours on either side of this one, being the same for the deepest visible crimson and full green. When the intensity of the different spectra is varied, the greater the intensity the more rapid is the rate of rotation necessary for flicker just to vanish. Research was made to discover in what way the rotation of a black and coloured disc must be varied for flicker to vanish, when the proportion of the coloured to the black sector varied by stages of 10° at a time, the experiments being carried out in each of the main colours of the limelight spectrum. The results are expressed in a series of remarkable curves.

The remainder of the paper is devoted to the discussion of these curves; and it concludes by proving, from a series of points taken at random on one of them, that the duration of the impression on the retina undiminished is within narrow limits inversely proportional to the time during which the retina is stimulated. Some other conclusions of interest are arrived at; *e.g.*, (1) When flicker has just vanished, the effective stimulus at any point of the retina is to the maximum stimulus the coloured sector can produce, as the angle of the yellow sector is to the angle of the whole disc (*i.e.* 360°), the illumination being supposed constant. (2) The coloured sector always requires a finite time in order to produce its maximum effect on the retina. (3) When the width of the white or coloured sector is increased in steps of 10° at a time, the increment in the apparent brightness in the rotating and flickerless disc follows, within the errors of experiment, the series of 1/0, 1/1, 1/2, 1/3, 1/4, etc.

AUTHOR.

1319. *Adjustable Röntgen-Ray Tubes.* **A. A. C. Swinton.** (Archives of the Röntgen Ray, 2. 3. pp. 40–46, 1898.)—The several methods of making X-ray tubes adjustable, described in Abstract No. 1218, are discussed from the point of view of practical radiography. That in which the anode is fixed, and the kathode is movable in and out of a glass annex, is preferred, as with it the point of origin of the rays is constant, while a travel of ½ inch is sufficient to alter the penetration from the highest to the lowest value, so that definition is not interfered with. Kathodes should be well polished and accurately curved. They should not be too small or they become overheated, nor very large, as in that case only the central portion is active. The platinum anti-kathode is best mounted on a massive block of aluminium, to absorb the heat and prevent deformation and blackening. Blackening increases the resistance, not only by occluding the residual gas but also by forming a non-fluorescent coating on the glass. The quantity of X-rays and their penetrative value are distinct. The latter depends largely upon the potential difference, but is independent of the material used for the anti-kathode. The quantity is, however, greatest with anti-kathodes of the highest atomic weight.

AUTHOR.

1320. *Pin-hole Röntgen-Ray Camera.* **A. A. C. Swinton.** (Archives of the Röntgen Ray, 3. 1. pp. 15–16, 1898.)—A pin-hole camera is employed to compare the active anti-kathode areas in various forms of focus-tubes, with a view of ascertaining the design best fitted to give the sharpest possible definition in radiographs. Endeavours to detect reflected Röntgen rays gave negative results.
AUTHOR.

1321. *Source of Röntgen Rays in Focus Tubes.* **A. A. C. Swinton.** (Roy. Soc. Proc. 63. pp. 432–437, 1898 ; also Nature, p. 286, 1898.)—The source is investigated with a pin-hole camera, fitted with a fluorescent focussing-screen. The dimensions and form of the source vary considerably when the distance between kathode and anti-kathode is altered. Those kathode rays which impinge most normally on the anti-kathode are most effective in producing Röntgen rays. The kathode stream usually proceeds almost entirely from a small central portion of the kathode surface. The kathode rays cross at the focus, and the divergent cone retains any special characteristics of the convergent cone. The main source of the Röntgen rays is on the anti-kathode, but an appreciable quantity also proceed from all those portions of the glass that show green fluorescence. This fluorescence is due to S. P. Thompson's para-kathodic rays, which start not from the kathode but from the anti-kathode. The Röntgen rays that come from the glass are generated by the impact of these para-kathodic rays; and the latter are most plentiful along the path in which the kathode rays would be reflected from the anti-kathode, according to the law of equal angles. AUTHOR.

1322. *Discharging Action of Uranite.* **E. Villari.** (N. Cimento, 7. pp. 46–50, 1898.)—The author shows that the radiation from uranium and its compounds, discovered by Becquerel, behaves in several respects like X-rays. The radiation from uranite imparts to air or coal-gas the power of discharging an electrified conductor, and this property persists for some time after the action of the radiation has ceased, becoming gradually more feeble. Air exposed to uranium radiation and then blown past the extremity of an electrified wire loses its power of discharging electricity of the same sign as that on the wire, but will still discharge electricity of the opposite sign. If the wire is held close to the end of the tube from which the gas emerges, the latter loses its power of discharging either kind of electricity. When wrapped in paper the uranite is no longer able to affect the air outside the paper ; either actual contact is necessary or, more probably, the active radiation is absorbed by the paper. A photographic plate, shut up in its dark slide, is not affected by the action of the mineral in 3 hours ; but an effect is produced by uraninite or uranium nitrate separated from the plate by two thicknesses of black paper. J. L. H.

1323. *Phosphorescence of Rarefied Gases.* **H. F. Newall.** (Cambridge Phil. Soc. Proc. 9. 6. pp. 295–302, 1897.)—Previous experiments on electric discharges in rarefied gases by Morrem, Sarasin, and J. J. Thomson, indicate that phosphorescence after cessation of the discharge only occurs in mixtures of gases, or simple gases which polymerise. The author's attention was drawn to the subject by observing brilliant phosphorescence in mixtures of oxygen with other gases when rendered luminous by electrodeless discharges. He finds that in all cases the spectrum of the phosphorescent glow is a continuous one, even when the pressure of the gas is only 0·1 mm. mercury; in no case have lines or bands been observed. On concentrating a beam of sunlight upon the phosphorescent gas no scattering of polarised light is observed, so that there is no evidence of the presence of solid particles in the gas. Black or brown deposits appear occasionally on the inside of the (electrodeless) glass tube; sometimes they form a thick film, and they indicate that chemical changes are produced by the discharge. The author connects white phosphorescence with mixtures of oxygen and carbon, yellow with oxygen and nitrogen, and blue with oxygen and sulphur. The afterglow appears at pressures between 0·01 and 0·6 mm., and is greatest at about 0·4 mm., the limits varying slightly for different gases. By altering the pressure during phosphorescence increased brightness may be produced.

When a mixture of gases is first compressed the operation renders it luminous; but if it be then rarefied and re-compressed it does not again glow, unless it be put in communication, while rarefied, with a bulb in which an electrodeless discharge is taking place. The author considers that the gaseous molecules form themselves into groups at low pressures, which are destroyed as the pressure is increased, and he describes phenomena supporting this view. The spectrum of the pressure-glow differs from that following electrical discharge, the pressure-glow containing four bright oxygen bands. The luminosity of condensing nebulæ may be due to pressure-glow; in the centre of the nebula the pressure is too great, and on the edge too small, for visible phosphorescence. The luminosity of the intermediate layer will be persistent on account of the streaming-in of rarefied gas, and will not point to a high temperature of the nebula. J. L. H.

HEAT.

1324. *Boiling-point Curve for Benzene and Alcohol.* **E. F. Thayer.** (Journ. Phys. Chem. 2. pp. 382–384, 1898.)—The minimum boiling-point for benzene-alcohol mixtures is 66°·7 C., the pressure being 73·7 cm. of mercury; the critical mixture contains 66·5 per cent. of benzene. R. E. B.

1325. *Specific Heat of Metals at Low Temperatures.* **C. C. Trowbridge.** (Science, 8. pp. 6–11, 1898.)—For Cu, Fe, Al, which gave ·0940, ·1162, ·2173 for the mean specific heats between 23° and 100° C., were found ·0868, ·0914, ·1833 for the mean specific heats between the boiling-point of oxygen ($-181°·4$ C.) and normal temperatures (11° to 15° C.). R. E. B.

1326. *Emissivity of Platinum.* **J. E. Petavel.** (Roy. Soc. Proc. 63. pp. 403–405, 1898.)—The emissivity of a bright Pt wire, ·112 cm. in diameter, which served both as radiator and thermometer, was measured in air, CO_2, H, O, and steam, at pressures from 1 to 228 cm. of mercury and at temperatures between 200° and 1779° C. The radiation of Pt between 500° and 1779° was also studied bolometrically, and Weber's radiation-formula was confirmed for temperatures between 400° and 800°, while the formulæ of Dulong and Petit, Stefan and Rosetti failed to express the experimental results obtained. The intrinsic brilliancy of Pt in candles' power per sq. cm. was found to be expressible in terms of degrees C by $\{(t-400)/889{\cdot}6\}^{6{\cdot}9}$. R. E. B.

1327. *Use of Standard Thermometers.* **A. W. Warrington.** (Chem. News, 78. pp. 6–7, 1898.)—An ordinary Jena thermometer, provided with a Reichsanstalt certificate, was compared with a Tonnelot standard from the Bureau International. By reading the Jena thermometer upright, stem immersed, correcting for zero point and for the errors detailed in the certificate, results were obtained in practical agreement with the Paris hydrogen scale, the mean error being only $\pm$ 0°·004. R. A. L.

1328. *Absolute Temperature.* **K. Schreber.** (Annal. Phys. Chem. 65. 3. pp. 648–654, 1898.)—The author points out the advantages of the "geometrical" scale of temperatures, based upon the percentage change of a certain property (volume, tension, etc.), in comparison with the generally adopted arithmetical scale. The laws and equations of thermodynamics admit of a simpler expression by means of the geometrical scale, which was originally

proposed by Dalton. It is the only scale which is absolutely independent of the properties of any given substance, and of speculations with regard to the absolute zero of temperature.

E. E. F.

1329. *Kinetic Theory of Gases.* **H. Staigmüller.** (Annal. Phys. Chem. 65. 3. pp. 655–669, 1898.)—This is an attempt to substitute definite conceptions of motion for the kinetic theory, which is solely based upon the two laws of thermodynamics. The motion of a gaseous molecule consisting of n atoms is completely defined by $3n$ independent variables. Three of these serve to fix the motion of translation of a single atom, and three more its rotation, with reference to two other atoms. Of the remaining $(3n-6)$ coordinates three give the mutual distances of the three atoms, and then the remaining coordinates of any further atoms may be determined with reference to the first three. If e is the mean value of the kinetic energy corresponding to the $3n$ coordinates, the total energy of the system is $6\ (n-1)e$. The author terms $6(n-1)$ the "heat dimension" of the gas, and denotes it by θ. The constant is characteristic of the thermal properties of a gas. It has the value 5 in the gases CO, NO, and the haloid acids, 7 in such bodies as water, CO_2, and SH_2, 18 in PCl_3 and $CHCl_3$, and 22 in the chlorides of silicon, tin, and titanium. The specific heat at constant pressure is calculated from the heat dimension by the formula

$$C_p = 0{\cdot}98835\frac{\theta+2}{\mu},$$

where μ is the molecular weight. This formula accords well with experiment.

E. E. F.

1330. *Law of Dulong and Petit.* **H. Staigmüller.** (Annal. Phys. Chem. 65. 3. pp. 670–672, 1898.)—The author attributes temperature to the mean kinetic energy of the atom vibrating about a mean position. He deduces from general principles the equation

$$\frac{1}{2}\frac{C'_v}{nN}=\frac{3}{\theta}\frac{C_v}{N},$$

where θ is the "heat dimension," n the number of atoms in the molecule, N the number of molecules in 1 gramme, C_v the gaseous and C'_v the solid specific heat. Putting $C_v=0{\cdot}98835\ \theta/\mu$ he obtains

$$aC'_v=5{\cdot}93,$$

a close approximation to Dulong and Petit's law.

E. E. F.

1331. *Absolute Measurement of Radiation.* **F. Kurlbaum.** (Annal. Phys. Chem. 65. 4. pp. 746–760, 1898.)—The author reduces the heat absorbed by the bolometer to a Joulean current heat, and thus makes it amenable to absolute measurement. The

bolometer is put into one gap of a Wheatstone bridge, the other three gaps being thick wires, whose resistances are not altered by the current. The bolometer is subject to radiation and its resistance noted. The same resistance is then produced by current heating, and a comparison of the resistances with and without radiation gives an absolute measure of the latter. The method is then used to determine the radiation of an "absolutely black" body. The radiation from such a body at 100° to another at 0° is found to be

$$0{\cdot}01763 \frac{\text{gr.-cal.}}{\text{cm.}^2 \text{ sec.}}$$

The author claims to be able to measure the radiation from any source in absolute measure with ease and accuracy. E. E. F.

SOUND.

1332. *Lecture-experiments on Sound.* **G. Bongiovanni.** (Rivista Scientifica, 30. pp. 123–131, 1898.)—The author describes the use of a spirally coiled wire to demonstrate the various equations for the velocity of sound, particularly

$$v = \sqrt{g/a},$$

where a is the elongation produced in the stretched spring, or

$$v = \mathrm{L}\sqrt{g/b},$$

where L is its length and b is actual extension. A. D.

1333. *Motion of Vibrating Strings.* **G. Klinkert.** (Annal. Phys. Chem. 65. 4. pp. 849–872, 1898.)—The motion of a string kept vibrating by means of an electromagnetic device is investigated by a stroboscopic method and by photography, after the method devised by Krigar-Menzel and Raps. In one arrangement the string acts as its own interrupter. The mode of vibration of the string, and the number and intensity of the overtones depend upon the position of the electromagnet, the place of the mercury contact, the depth of immersion of the platinum point, and the tension of the string. To produce any required overtone, the electromagnet should be placed immediately over the first ventral segment, where the amplitude of the vibration is greatest in comparison with that of the fundamental. The third harmonic is difficult to eliminate, except by employing an auxiliary string to act as interrupter for the string under examination. E. E. F.

1334. *Tuning-forks.* **C. Stumpf** and **M. Meyer.** (Annal. Phys. Chem. 65. 3. pp. 641–644, 1898.)—This is a renewed criticism of Appunn's standard tuning-forks and whistles. The authors point out that calculation from geometrical dimensions cannot be relied upon to govern even the correct octave of the very high notes. E. E. F.

1335. *Tuning-forks.* **F. Melde.** (Annal. Phys. Chem. 65. 3. pp. 645–647, 1898.)—This paper confirms the criticism of the previous one, and shows that the values attached to Appunn's standards are far too high. E. E. F.

1336. *Voice from Phonographs.* **Marage.** (Comptes Rendus, 126. p. 1202, 1898.)—New harmonics alter the vowels: these come mainly from the mouth-tube, partly from the vibrating disc. Altering the speed of rotation affects the pitch of the vowel-note, and modifies or transforms the vowel completely. The greater or less conicity of the resonator affects the loudness very little: the resonator must not import new vibrations of its own. The loudness increases, within limits, with the size of the vibrating disc: it seems to be also proportional to the pressure of the style on the vibrating disc and on the cylinder. A. D.

ELECTRICITY.

1337. *Electric and Magnetic Field produced by a Moving Charged Point.* **A. Liénard.** (Écl. Électr. 16. pp. 5–14, 53–59, & 106–112, 1898.)—The differential equations of the electromagnetic field can be put in the form

$$\left(V^2\Delta - \frac{d^2}{dt^2}\right)\psi = -4\pi V^2 \rho,$$

where ψ corresponds to the potential $\iiint \frac{\rho}{r} dx\, dy\, dz$ in the theory of instantaneous action. Corresponding expressions hold for F, G, H, the components of vector-potential. The most general integral is

$$\psi = \int \frac{\rho\left[x'y'z'\left(t - \frac{r}{V}\right)\right]}{r} d\omega',$$

r being the distance from M where ψ at time t is required to $x'\,y'\,z'$, $d\omega'$ an element of volume at $x'\,y'\,z'$, and ρ the density at $x'\,y'\,z'$ at the time $t - \frac{r}{V}$. V is the velocity of light. M. Liénard shows that, the whole charge e being contained in a very small volume and moving with velocity u, we may write

$$\psi = \frac{e}{r\left[1 - \frac{u}{V}\cos(ur)\right]},$$

from which and the corresponding expressions for F G H he finds the components of displacement $f\,g\,h$, and of magnetic force $\alpha\,\beta\,\gamma$, at M at time t. The results are applied to (i.) a closed circuit; (ii.) the loss of energy by radiation; (iii.) the force exerted on itself by a charged particle in motion. The consequences of u being assumed greater than V are discussed.

S. H. B

1338. *Electromagnetic Hypotheses.* **E. Wiechert.** (Göttingen Nachrichten, 1. pp. 87–106, 1898.)—These hypotheses are a modification and extension of Maxwell's electromagnetic theory, and the endeavour is made to include in their scope such recent work as kathode rays and Zeeman's phenomenon. E. H. B.

1339. *Atmospheric Discharges of Electricity.* **S. A. Montel.** (Écl. Électr. 16. pp. 183–188, 1898.)—An electrified cloud and the earth, or two oppositely electrified clouds may be considered as forming a condenser, the discharge of which is a flash of lightning.

If there be in the neighbourhood a closed circuit without electromotive force of its own, the flash induces in the circuit a transient current. In the author's notation, Q is the absolute quantity of electricity on either armature of the condenser; C the capacity of the condenser; L the coefficient of self-induction of the primary circuit, *i. e.* the course of the flash; L′ the coefficient of self-induction of the induced circuit; M the coefficient of mutual induction; R R′ the resistances; $i\,i'$ the intensities at time t. Applying the usual formulæ, the writer considers two cases, (1) that the discharge is continuous; (2) that it is oscillatory. Making

$$m=\sqrt{\frac{1}{CL}-\frac{R^2}{4L^2}},$$

$$f=\frac{Q}{mLC}, \qquad \beta=\frac{R}{2L},$$

we have
$$i=f\epsilon^{-\beta t}\sin mt,$$

from which the induced current i' is obtained. The results for the cases (1) and (2) are given in a table. In case of an oscillating discharge, if m/β be very great, $\int i'^2dt$ is independent of $\frac{R'}{L'}$. If m/β be not very great, $\int i'^2dt$ is generally greater as $\frac{R'}{L'}$ is smaller. He concludes that if we have two induced circuits, for one of which $\frac{R'}{L'}$ is very great, and for the other very small, it may be possible, by measuring the quantities $\int i'^2dt$ in the two cases separately, to determine, within limits, the nature of the atmospheric discharge. S. H. B.

1340. *Ultra-Violet Light and Conductivity of Vapours.* **J. Henry.** (Cambridge Phil. Soc. Proc. 9. 6. pp. 319–322, 1897.) —Experiments are described which show that the rate of leakage of electricity from a charged copper disc exposed to ultra-violet light is not increased, but rather diminished, by surrounding the disc with an atmosphere of iodine or amyl-nitrite vapour. The author concludes that these vapours are not rendered conductors by absorption of ultra-violet radiation. J. L. H.

1341. *Contact-Electricity of Metals.* **Kelvin.** (Phil. Mag. 46. pp. 82–120, 1898; a paper read at the Royal Institution, May 21st, 1897.)—The first part of this paper is historical. Volta's fundamental experiments and others are described and deductions drawn from them. The author's own researches upon the measurement of contact-force, and those of Pellat, Pfaff, Bottomley, and Erskine-Murray are referred to. The author then discusses thermo-electric E.M.F. If a closed circuit consisting of, say, copper and iron is

broken at one of the junctions, and a quadrant electrometer inserted, the deflection will be a measure of the contact-force + the thermoelectric E.M.F. due to any difference of temperature between the junctions. If a copper plate is allowed to move inwards in the gap, moving on the copper part of the circuit (which is supposed to be of large cross-section), cold will be produced at the other junction; if it is drawn out heat will be evolved, but such heat is not the thermal equivalent of the work done: probably the greater part of the work done in drawing out the plate against the electric attraction goes to storing up electrostatic energy. Reasons are then given in support of the view that the Peltier evolution of heat is not the thermal equivalent of E.M.F. at a junction.

Volta's experiments render it certain that two metallically connected pieces of metal attract one another, the force of attraction being a resultant of chemical affinity between thin surface-layers of the two metals. The work done by electric attraction in allowing two such plates of copper and zinc to approach each other is calculated for various distances ranging from 1/100 cm. to $1/10^{10}$ cm. The value of the force, heat evolved, and rise in temperature are also given. It is inferred that the attraction does not vary inversely as the square of the distance for such small distances as $1/10^9$ cm., because the value of the force then becomes so large as to be inadmissible; at smaller distances the electric attraction merges into molecular force between the metals. Suppose a disc of zinc to be metallically connected with a disc of copper at some distance from it, then disconnected and brought near to the copper; no work is done in this movement by the electric attraction. If connection is now made, current flows and heat is generated. Imagine a pile of alternate discs made up in this way, and finally metallic connection made between all the discs. If the discs are thin, and the distances between them are suitably small, sufficient heat will be generated to give a column of brass. This would take place if we suppose the electric attraction to vary inversely as the distance for discs 10^{-8} cm. thick at a distance of 10^{-9} cm. apart, and the resulting heat would be much the same as the heat of formation of brass experimentally determined. The author concludes with an argument against Lodge's chemical theory of contact-force and with experiments on uranium rays. W. R. C.

1342. *Spark Discharge.* **R. Swyngedauw.** (Annal. Phys. Chem. 65. 3. pp. 543–552, 1898.)—This is a reply to G. Jaumann, who denies that if two different spark-gaps have the same potential with a static charge, they also have the same potential with a dynamic charge, provided the electrodes are polished and protected from radiation capable of provoking the discharge. The author points out that Jaumann's branch-circuit experiment disproves his own proposition. Further, according to Jaumann, the discharge-potential of an exciter which is charged by an influence-machine is much less than the discharge-potential measured according to

the static method, in which the charges are in equilibrium at any given instant. The author points out that the oscillations supposed to accompany the charging process have never been proved to exist, and that the balance of evidence is in favour of the charge by an influence-machine being static. E. E. F.

1343. *Flame Gases and Electric Discharges.* **K. Wesendonck.** (Annal. Phys. Chem. 65. 3. pp. 553–566, 1898.)—To investigate the cause of the comparative immunity of factory chimneys from lightning discharges, the author reproduces the conditions as far as possible by mounting a horizontal copper tube on a stand, and attaching to one end of it a miniature lightning-conductor, the other end being bent down and serving as an inlet for the products of combustion of a Bunsen burner or other flame. Opposite the lightning-conductor is mounted a metallic disc charged by an influence-machine, and representing an electrified cloud. To prevent discharge from the "chimney," the near end is surrounded by a separate cylinder with a rounded edge. When the machine is working steadily, and the distances are properly chosen, there is a steady glow-discharge between the positive rod and the negative disc, and an electrometer connected with the disc has a constant deflection. On putting a flame under the chimney, the glow is replaced by a brush- or spark-discharge. It is remarkable how sensitive the glow is even to small quantities of products of combustion. When the air of the room contains a certain proportion of them, the glow does not reappear until the air is renewed. When the machine is worked slowly and a brush-discharge is just about to pass into a glow-discharge, flame-gases stop the discharge until the potential rises and a brush-discharge breaks forth again. Sparks are also called forth by products of combustion which have been kept for some time in a copper box, by air containing steam, by simple streams of gas. The author ascribes the immunity of chimneys and the effects observed to the presence of streams of gases of certain substances, or of special temperatures and velocities. E. E. F.

1344. *Galvanometry of Spark Discharges.* **A. Witting.** (Annal. Phys. Chem. 65. 3. pp. 621–628, 1898.)—If a multiple influence machine is worked at a constant speed by a motor, and the stream of sparks is sent through a Wiedemann galvanometer of long period, the constant deflection obtained may be measured by the ordinary methods. But if the machine is worked by hand, the deflection undergoes irregular oscillations about a mean value, and the pitch of the note produced by the sparks oscillates correspondingly. The mean current may be obtained by a large number of successive observations or by noting the mean pitch of the note and the corresponding deflection. But surer ways are offered by "multiplication" and by Toepler's reversals. These give better deflections, and are in themselves mean-value methods. They may be described as follows:—On sending the current of sparks through the coil of

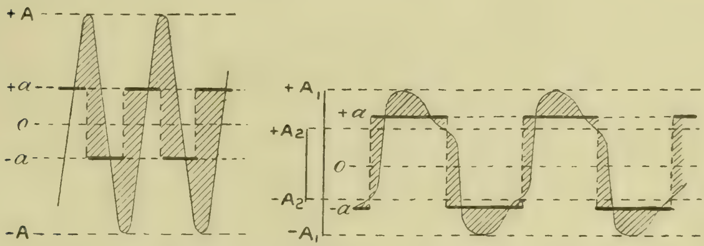
the galvanometer, the needle is deflected from its position of rest in the magnetic meridian and commences to oscillate about a new value, whose distance from zero may be denoted by $+a$. But the current is reversed at the first turning point of the needle, and the new position of equilibrium is therefore $-a$. If the reversal is repeated at every first turning point, a limiting state is eventually reached in which the needle attains alternately two elongations symmetrical to the zero, $+A$ and $-A$, and

$$(1) \quad \ldots\ldots\ldots \quad a = \frac{k-1}{k+1} A ;$$

$$(2) \quad \ldots\ldots\ldots \quad k = \frac{A+a}{A-a} = \text{the damping ratio.}$$

This method may be called that of simple multiplication.

The method of simple reversal is obtained by reversing the current not at every first, but at every second turning point of the needle, so that in the final state the needle attains four successive elongations $+A_1$, $+A_2$, $-A_1$, and $-A_2$. The two cases are illustrated in the diagram.



Generally, if the needle executes n oscillations about the mean values $+a$ and $-a$, odd n gives a multiplication method, and even n a reversal method, and

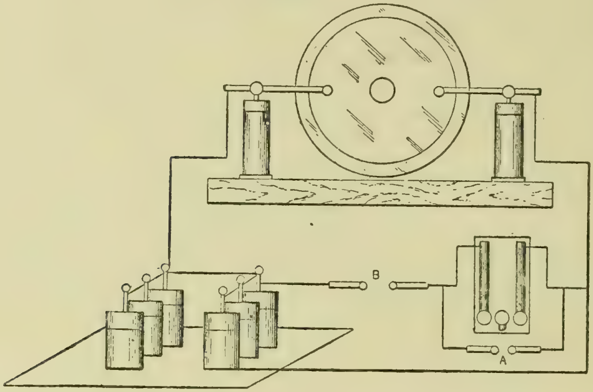
$$a = \frac{kA_1 - A_n}{1+k}.$$

The fundamental difference between these methods and the ballistic method, is that in the latter the impulse is given at the maximum speed of the needle (at zero deflection), whereas in the new methods the impulse is given at zero speed (at maximum deflection).

The author made a number of experiments by the new methods, in order to determine the relation between the strength of the current and the various elements of the circuit. He found that the current-strength is practically independent of the resistance in the circuit and of the length of the spark-gap, except that with long spark-gaps a considerable loss by radiation took place unless U-tubes containing $CuSO_4$ solution were inserted. Further, the current-strength was found within wide limits to be proportional to the speed at which the machine was worked. E. E. F.

1345. *Disruptive Discharge, Leakage and Ohmic Resistance.* **A. J. Wurts.** (Elect. World, 32. pp. 91–92, 1898.)—This is an account of some experiments on the relative values of lightning arresters with and without resistances in series with the spark-gap. The method of experiment is as follows:—A static machine (see fig. 1) driven by an electric motor at constant speed is used

Fig. 1.



to charge a battery of Leyden jars, the latter discharging across an initial spark-gap B and then through two paths connected in shunt to each other, one of these being the resistance it is desired to measure, and the other an adjustable spark-gap A. When the disruptive discharges pass over B, and then indifferently through the resistance to be measured and the variable spark-gap A, the length of the A gap may be taken as a measure of the resistance under test offers to the passage of disruptive discharges.

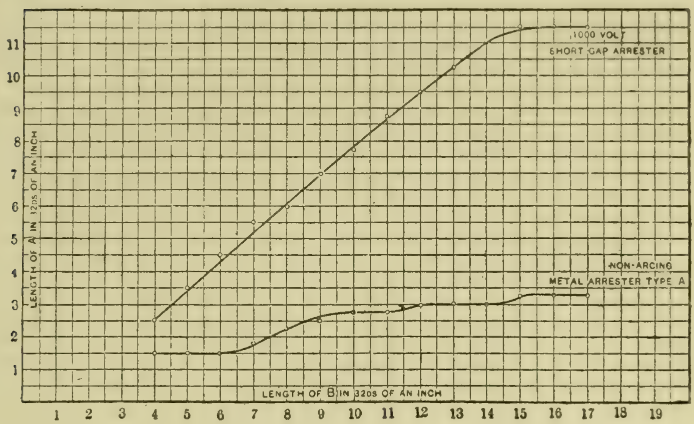
In the experiments the lengths of A and B are measured in thirty-seconds of an inch. First, with a value of B equal to 12, comparative measurements are made between a short-gap lightning arrester having 120 ohms resistance and two gaps aggregating one-sixteenth inch air-space, and a series of six gaps aggregating eleven sixty-fourths inch air-space, forming the standard non-arcing metal lightning arrester. With the former the gap A has a value 9 and with the latter only 2·75, showing that a non-inductive resistance in series with two spark-gaps offers over three times the resistance to disruptive discharge that six gaps offer without resistance in series.

On removing the spark-gap A and placing first one and then the other arrester in series with B, the following results are obtained:—

	Number of Discharges.	Duration in minutes.	Rate per minute.
Non-arcing metal......	50	5	10·0
" " "	40	5	8·0
Short gap	62	5	12·4
" "	55	5	11·0

From this result it would appear that the ohmic resistance does not allow complete discharge of the Leyden jars; consequently it requires less time to re-charge the jars, and the discharges occur more frequently. Fig. 2 shows the relation between the spark-

Fig. 2.



gaps A and B when both are varied and when the non-arcing metal and the short-gap arrester are respectively in shunt with A. The experiments throughout encourage the use of the non-arcing metal arrester. W. G. R

1346. *Kathode Jets.* **C. E. S. Phillips.** (Electrician, 41. pp. 425–426, 1898.)—This article describes an experiment to show that the green flecks, which appear upon the inner surface of a highly-exhausted and electrically-stimulated Crookes' vacuum-tube, have their origin in jets which emanate from the negative electrode. The special form of vacuum-tube employed by the author was so constructed that the kathode carried upon its inner extremity a small disc of aluminium, free to rotate, and movable when necessary through the action of an external magnet suitably arranged to affect an insulated iron projection from the edge of the disc itself. The tube having been highly exhausted, a discharge was passed through it until green flecks made their appearance upon the inner surface of the glass, and these moved correspondingly when the kathode disc was partially rotated. On stopping the discharge, a few of the luminous patches could still be seen clinging to the walls of the tube, sometimes shimmering for as long as 10 seconds. A movement of the disc again produced a corresponding movement of the patches, showing that the electrode continued to give off a radiation long after the discharge in the tube had ceased to pass. Any slight direct influence of the external magnet upon the movements of the green patches was carefully eliminated, and the

conclusion arrived at that not only is the position of these patches determined by the position of the negative electrode, but also that the jet-like emissions to which they owe their origin continue to be given off for some seconds after the stimulation of the tube has ceased. The effect of modifying the electrostatic condition of the glass walls is also incidentally mentioned, while its bearing upon the formation of the jets leads to a suggestion that many of the phenomena observed in focus-tubes may be better understood through a study of this curious action. AUTHOR.

1347. *Magnetic Deflection of Kathode Rays.* **A. Schuster.** (Annal. Phys. Chem. 65. 4. pp. 877–884, 1898.)—The author investigates the discrepancy between the values for e/m deduced by him from his experiments on the magnetic deflection of kathode rays and those obtained from Kaufmann's more recent experiments, which are about five times greater. The author's experiments, begun in 1888, were made with a thin cylindrical kathode beam bent into a circular arc by means of a strong magnetic field. In the original calculation only the curvature of the part of the beam adjoining the kathode was taken into account, although it increased further off. Allowing for this fact, and also for an increase in the potential-gradient, values are obtained which more closely agree with those of Kaufmann. Further experiments show that when the diameter of the ring is lessened, either by diminishing the potential-gradient or by increasing the strength of field, the quantity e/m is apparently increased. Still, Kaufmann's theory of the magnetic deflection is incomplete, and is only capable of indicating a superior limit of the ratio e/m. In Thomson's and Lenard's experiments no assumptions are made concerning the ratio of the velocity to the potential-gradient, but the calculations are based upon electrostatic repulsion. Lenard finds a mean value of $6{\cdot}4 \times 10^6$, and J. J. Thomson $7{\cdot}4 \times 10^6$. These are about midway between those found by the author and by Kaufmann respectively. These values are probably vitiated by the uncertainty as to the actual constitution of the gas in the tubes, which has a considerable influence upon the potential-gradient. It is interesting to note that Lorentz's value, deduced from Zeeman's experiments, is 10×10^6. This would indicate an equality between the particles producing luminous vibrations and kathode rays respectively, which would be of supreme theoretical importance. E. E. F.

1348. *Waves in a Medium of Periodic Discontinuity.* **H. Lamb.** (Mem. Manchester Lit. & Phil. Soc. 42. 3. pp. 1–20, 1898.)—The main object of this paper is to illustrate the selective total reflection which takes place at the boundary of a medium of the above constitution. In the examples chosen for discussion, the medium is represented by a string supposed to be capable of longitudinal

vibrations, and the periodic interruption of properties consists, in one case, of a series of equal particles attached at equal intervals; in another, these particles are urged towards fixed positions by elastic springs; whilst in a third example they are supposed to be connected to the string through the intermediary of springs. It is further shown how the methods can be extended to the case where equal and similar dynamical systems, of any degree of complexity, are inserted at regular intervals. The same analysis applies when the intervening medium consists of a tense string capable of transversal vibrations and to many other cases.

The case where the masses have an elastic connection with the vibrating string appears to illustrate the theory of refraction sketched by Sir G. Stokes in the 'Wilde Lecture' for 1897. At all events, the analysis shows that the one-dimensional medium under discussion has the following characteristics:—

(1) It possesses for sufficiently long waves a definite index of refraction, with coefficients of reflection and transmission related to this index in the usual manner.

(2) It totally reflects radiations of wave-lengths lying between certain limits.

(3) For sufficiently short waves it allows, as a rule, free transmission, with practically no reflection. E. H. B.

1349. *Measurement of Hertzian Oscillations.* **A. Ekström.** (Annal. Phys. Chem. 64. 2. pp. 315–324, 1898.)—When an electric oscillation is propagated along a wire reflections take place at each end of the wire, and the interference-curve obtained by taking electrometer or bolometer measurements at each point on the wire is usually a complex one. The author shows that if the wire be a long one, the interference-curve at a great distance from the oscillator has the same form as the primary oscillation. With shorter wires of variable length the form of the interference-curve depends on the length and contains harmonic overtones in addition to the fundamental oscillation. Four types of interference-curve are given, to one or other of which the curves found by different physicists belong. J. L. H.

1350. *Influence of Frequency upon Capacity.* **J. Hanauer.** (Annal. Phys. Chem. 65. 4. pp. 789–814, 1898.)—Both in solids and in semi-conducting liquid dielectrics the capacity of a condenser varies with the frequency of the alternate current used. In the solid dielectrics a loss of energy occurs at the same time, which increases with the period and with the variation of capacity. The phenomenon appears to be connected with residual discharge, and an explanation must be sought in a lack of homogeneity in the dielectric. In liquids the change of capacity with frequency is considerably reduced by platinising the condenser-plates. Calculation shows that polarisation must exert an influence upon the

capacity of a liquid condenser. Probably, therefore, polarisation accounts for the observed variation, and we have here no phenomenon of electric dispersion. E. E. F.

1351. *Thermal Phenomena in Condenser Circuits: Part I., Electrolytes.* **P. Cardani.** (N. Cimento, 7. pp. 23–45, 1898.)—The resistance of a metallic conductor is greater for alternating currents of high frequency than for steady currents, because in the former case the current tends to keep to the surface of the conductor. Stefan has shown that theoretically no such difference ought to exist in electrolytes, the distribution of current throughout the section of the electrolyte being the same for all frequencies. The author describes experiments which confirm the theoretical deductions of Stefan. A circuit is arranged containing a condenser, a platinum wire enclosed in the bulb of a petroleum thermometer, and a spark-gap similarly enclosed in an air-thermometer; the circuit also includes a tube of the electrolyte of variable length and cross-section. In the experiments the self-induction of the circuit and the length of the spark-gap are kept constant, and the change of thermometer-reading produced by twenty condenser discharges is observed for columns of electrolyte of varied length, cross-section, and material, correction being made for radiation from the surface of the thermometer. The results show that the resistance of a column of electrolyte of length L and sectional area S, is KL/S, the value of the specific resistance K being the same for the condenser-discharges as for steady currents. The experiments suggest a new method of measuring electrolytic resistance, which is free from many of the inconveniences of the present methods. J. L. H.

1352. *Resistivity of Steels.* **H. Le Chatelier.** (Comptes Rendus, 126. pp. 1709–1711, 1898.)—The specimens of steel experimented on were in the form of bars 20 cms. long and 1 cm. square; they were annealed several hours at 600° C. In the following table the numbers express the specific resistances in microhms per centimetre cube:—

Influence of Carbon.

Resistance.	Composition.		
	C.	Mn.	Si.
10	0·06	0·13	0·05
12·5	0·20	0·15	0·08
14	0·49	0·24	0·05
16	0·84	0·24	0·13
18	1·21	0·21	0·11
18·4	1·40	0·14	0·09
19	1·61	0·13	0·08

The resistance clearly increases with the amount of carbon, its increase is on an average 7 microhms for one per cent. of carbon

by weight, or 1·5 microhm for one atom of carbon per 100 atoms of iron and carbon.

Influence of Silicon.—An increase of 14 microhms for 1 per cent. of silicon by weight, or 7 microhms for one atom of silicon per 100 atoms of alloy. The author is lead to the conclusion that in steel the silicon is not isolated in the form of a definite silicide $FeSi_2$, but is found in the form of a homogeneous mixture, solid solution, or isomorphous mixture.

Influence of Manganese.—Manganese considerably augments the resistance of steel. This metal, isomorphous with iron, forms with it homogeneous mixtures in all proportions. These mixtures can, however, exist in two allotropic states, unequally magnetic and also possessing resistances notably different. The experiments show an increase of resistance about 5 microhms for 1 per cent. of manganese by weight or in atoms for the non-magnetic alloy. For the magnetic (obtained by annealing 2 hours at 550°) this increase of resistance is only 3·5 microhms.—The paper also deals with the influence of nickel, chromium, tungsten, and molybdenum.

E. C. R.

1353. *Effect of Tempering on Resistivity of Steel.* **H. Le Chatelier.** (Comptes Rendus, 126. pp. 1782–1785, 1898.)—Tables are given showing the increase of resistance after tempering at various temperatures, ranging from 710° to 1100°; the samples tested were 2 ordinary steels, 4 tungsten steels, and 3 chrome steels. At high temperatures chromium adds to the increase of resistance due to the carbon alone; tungsten, on the other hand, diminishes it. In all cases the resistance increases with the increase of the temperature up to a limiting value depending on the constitution of the steel. G. B. M.

1354. *High Pressure Experimental Battery.* **A. C. Longden.** (Elect. World, 31. p. 681, 1898.)—A high-pressure battery may be formed of zinc and copper couples, which are dipped into water just before use; but the internal resistance is very high. If acid is used, local action is troublesome. The author overcomes these difficulties by using, in place of zinc, copper amalgamated with zinc amalgam, the plates being allowed to stand in a small quantity of zinc amalgam at the bottom of the cell. A compact battery may be made out of small homœopathic vials which, when charged with one-per-cent. acid, gives no trouble and has a comparatively small internal resistance. W. R. C.

1355. *Standards of E.M.F.* **W. Jaeger** and **K. Kahle.** (Annal. Phys. Chem. 65. 4. pp. 926–942, 1898.)—Standards of E.M.F. offer a ready and accurate means of producing a standard current, although in the last instance a silver voltameter has to be called into use. But with the latter it is difficult to attain an accuracy of 0·01 per cent., whereas that is easily attained by a

combination of the Clark and the Weston cells. Such a combination furnishes more than twice the security of a single cell, since not only the constancy of the two elements separately but also the constancy of their ratio may be treated. If, besides the constant differences between two elements of the same kind, this ratio also remains constant, it may safely be assumed that the cells themselves have remained constant. To establish this conclusion, the authors have determined the E.M.F. of a large number of zinc and of cadmium standard cells of various ages with the aid of the Reichsanstalt silver voltameter, and have redetermined the temperature coefficients of both the standard cells. Out of 27 Clark cells constructed since 1891, one showed a decrease in the E.M.F. of 0·14 millivolt in one year. Out of 41 Weston cells, one showed an increase of 0·18 millivolt in two months. These were the maximum variations. In the case of the cadmium cell referred to, the excess fell to 0·08 millivolt in three years after construction. The values as redetermined are :—

E.M.F. Clark cell .... 1·4328 intern. volts at 15° C.
„ Weston cell .. 1·0186 „ „ 20° C.

Temperature coefficient of Clark cell:

$$= -0{\cdot}00119\,(t-15) - 0{\cdot}000007\,(t-15)^2.$$

Temperature coefficient of cadmium cell:

$$= -0{\cdot}000038\,(t-20) - 0{\cdot}00000065\,(t-20)^2.$$

E. E. F.

1356. *Reactions in Accumulators.* **G. Darrieus.** (Écl. Électr. 14. pp. 141–155, 229–237, 370–374, 498–503, and 555–561, 1898.)—These papers are the result of an experimental study of accumulators, chiefly of the lead type. By means of analysis after charging and again after discharging, the author arrives at the following conclusions, chiefly in opposition to the double sulphate theory. Persulphuric acid is immediately formed as soon as charging begins, and its appearance is more marked the stronger the sulphuric acid. The active matter on the positive after charging is simply PbO_2, and on the negative spongy lead containing traces of free hydrogen. After discharge, the amount of PbO_2 reduced depends on the number of ampere-hours of discharge, but this is not true of the amount of sulphate formed. On the other hand, the lead sulphate formed on the negative is proportional to the ampere-hours of discharge. If sodium-sulphate solution is substituted for the sulphuric acid in a charged cell which is subsequently discharged, it is found that only a trace of sulphate is formed on either plate, and when the negative active material after this discharge is heated in a gas flame it becomes incandescent, giving a mixture of litharge and metallic lead. From this it is inferred that the reaction at the negative is simply one of oxidation, the sulphating being due to a secondary reaction. Partial discharge may be brought about by allowing the negatives to oxidise in the air. With regard to the positives it would appear that the PbO

is simply the depolariser, being reduced to PbO, which is then converted into sulphate by local action between PbO_2 and PbO. The action of persulphuric acid in charging is necessary as an oxidant. The preceding remarks relate to the flat parts of the charge and discharge curves; the steep parts are fully accounted for by the presence of persulphuric acid and free hydrogen. The E.M.F., as calculated from Kelvin's law, is shown to practically agree with the experimental value, if it is allowed that the spongy lead is in a different molecular state to the ordinary metal.—The author then passes on to further experimental proofs. Oxides lower than PbO_2 are capable of existing in dilute sulphuric acid. The rapid rise of E.M.F. at the end of a charge is due to the formation of exothermic bodies, and not to unequal density of acid about the plates as contended by Gladstone and Hibbert. The amount of acid held by either plate is found to be about the same. Experiments with artificial positives made out of mixtures of PbO_2 and PbO, or PbO_2 and $PbSO_4$, show that the discharge curve closely approximates the usual form in the case of the latter, and that only 15 % of PbO_2 (chemically formed) is necessary in this mixture to give an E.M.F. of 1·99 volts. It is thus desirable to facilitate the local action on the positive. The ideal plate should consist of molecules of peroxide, each with a conducting molecule alongside. Local action on the negative is, of course, to be avoided. Amalgamation of these raises the E.M.F. by 0·11 volt, increases the capacity and diminishes local action; but these results are not permanent. Disintegration of positives is more probably due to liberation of oxygen in charging than to changes of volume. The author concludes with experiments on aluminium, antimony, copper, and platinum, used as plates, the results of which have a bearing upon the double sulphate theory. Many interesting experiments are described which cannot be included in a short abstract. W. R. C.

1357. *Lead Accumulators.* **F. Dolezalek.** (Annal. Phys. Chem. 65. 4. pp. 894–916, 1898.)—A paper on the same lines as that noticed in Abstract No. 689. E. E. F.

1358. *Aluminium Electrodes in Electrolytic Cells.* **E. Wilson.** (Roy. Soc. Proc. 63. pp. 329–347, 1898.)—In Part I. aluminium-carbon cells are experimented upon with direct currents, the electrolytes being alum solution, dilute H_2SO_4, and aqueous NaOH. For the purpose of allocating the distribution of potential-difference in the cell an exploring electrode was placed between the plates. After establishing the well-known effect, that it is between the electrolyte and aluminium when used as an anode that the apparent great resistance takes place, a series of experiments were made to find the effect of variation of current-density and temperature upon the potential-difference between the plates. With the temperature rising from 13° to 20° C., and a variation of current-density from ·00011 to ·04 ampere per square inch of Al anode

the potential-difference rose in alum from 1·9 to 34·5 volts. With approximately constant current-density of ·019, the potential-difference fell from 30 to 3 volts as the temperature of the cell rose from 13° to 70° C. No material increase of potential-difference was found on cooling the cell by freezing. A microscopic examination and chemical analysis, by H. Jackson, of one of the films formed on the Al plate, show that it is full of minute cracks giving the impression of a dried gelatinous pellicle, not unexpected if the plate had been covered when wet with gelatinous aluminium hydroxide. The analysis shows the film to consist of basic aluminium sulphate. An experiment was made upon a film formed without the passage of current, by first submerging a bright Al plate in alum solution, and then exposing it to the atmosphere. The conclusion is that this film has the same effect as another formed during the passage of current. Such a film when dry had an electrical resistance of about 10,000 ohms.

In Part II. the subject of Alternate Currents is dealt with. Experimenting first with aluminium and carbon plates in alum solution, the frequency was varied from 16 to 98 periods per second, and the current-density varied from ·04 to ·58 ampere per square inch of the Al plate. The result is that large phase-difference between current and potential-difference occurs with the small current-densities; but a large ratio between the maximum coulombs in the halves of a period, which is the effect looked for, has not time to properly develop with the frequencies mentioned. It is shown that a uni-directional current can be obtained by an arrangement of these cells proposed by Graetz, and the efficiency is discussed. The concluding experiments deal with the suitability of aluminium when forming the plates of condensers for alternate currents. Soda, ammonia, and potash alum solutions, when saturated and non-saturated, were employed as electrolytes. The current-densities were varied from ·014 to ·6, and the frequency from 7·5 to 100. Phase-differences of the order of $\frac{1}{6}$th period can be obtained by a suitable choice of current-density and temperature.

AUTHOR.

1359. *New Absolute Electrodynamometer.* **M. Deprez.** (Comptes Rendus, 126. pp. 1608–1610, 1898.)—Let a perfectly regular coil, of any number of layers, be wound solenoidally upon a tore of revolution. Inside the tore place a circular cylindrical coil, movable about an axis of rotation which is in the diametral plane of the tore, and perpendicular both to the axis of the tore and to the axis of the cylinder; and let the axis of rotation pass through the centre of the cylinder. When the axis of the cylinder is parallel to that of the tore, and currents I, I′ are sent through the coils, the couple on the inner coil about the axis of rotation is rigorously $2NII'\Sigma(S)/a$, where $\Sigma(S)$ is the sum of the areas enclosed by the turns of the movable coil; N the number of turns wound on the tore; and a the distance of the centre of the movable coil from the axis of the tore.

G. B. M.

1360. *Guye's Electrostatic Wattmeter.* (Écl. Électr. 15. pp. 114–115, 1898.)—The needle turns on knife-edges in a vertical plane and consists of two aluminium semicircles, having their diameters horizontal, fixed into an ebonite piece which insulates them one from the other and carries the knife-edges. The pointer is attached to the upper semicircle, and a rod, with adjustable weight providing the controlling force, to the lower. This needle swings between two pairs of fixed semicircular brass plates, the pairs being separated along the vertical; the distance between the two plates of each pair can be adjusted by means of distance pieces slipped over their screwed supports. The two main circuit terminals are connected to these two pairs, and the two semicircular sectors of the needle are connected to the ends of a non-inductive resistance carrying the current. G. H. Ba

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1361. *Alternate Current Wattmeter.* **H. Behn-Eschenburg.** (Ann. Ass. Suisse Électr. 8. pp. 43–51, 1897.)—The wattmeter is on the principle of the d'Arsonval galvanometer, the fixed magnet being energised by the main current, and the moving coil taking current from a shunt across the mains. The axis of the moving coil is perpendicular to the plane of the horseshoe fixed magnet. The shunt consists of an inductionless resistance, one end joined to one main, the other to two resistances in parallel; of these, one is inductionless and completes the circuit directly to the other main, and the other is inductive and completes the shunt circuit through the moving coil. The object of the small inductive resistance inserted in series with the moving coil is to balance the effect of the hysteresis in the main circuit. The latter produces a phase-difference of about 5°, and by suitably adjusting the inductance of the shunt-circuit, according to calculations given in the paper, a similar phase-difference is created in the shunt-circuit and the effect of hysteresis balanced at any frequency. G. H. Ba.

1362. *Correction Factors of Wattmeters.* **M. Aliamet.** (Électricien, 15. pp. 386–389, 1898.)—The author shows by simple graphical methods that a wattmeter whose thin coil has sensible reactance always gives incorrect readings, even if it is carefully standardised, unless the reactances of the thin coil and the main circuit including the thick coil are equal and opposite. The readings are of course correct if the reactance of the thin coil is zero.

W. G. R.

1363. *Coherers.* **L. Arons.** (Annal. Phys. Chem. 65. 3. pp. 567–571, 1898.)—Coherers were prepared by cutting a fine line across a thin strip of tinfoil stuck on glass, laying a little metallic powder over it, adding a drop of Canada balsam, and covering it with a cover-glass. In this manner the whole field of action could be brought within the range of the microscope. The Canada balsam did not interfere with the efficiency of the coherer, a fact which gives some idea of the energy of the reaction. The newly

prepared coherers had an infinite resistance. On exposing them to the impact of electric waves full contact was as a rule immediately produced, especially when the particles were at all dense. Under the microscope violent commotions and a play of sparks were observed among the particles. The green sparks between silver particles were specially bright. Usually the contact could be annulled by tapping. Sometimes, especially in the case of brass filings, one or two particles would stick on hard, and their surfaces showed signs of oxidation. They had to be removed by a brush. When the particles were embedded in Canada balsam, a light pressure on the cover-glass sufficed to annul the conductivity. A peculiar phenomenon observed was the destruction of contacts by a repetition of the vibrations which produced them. The liquid of the embedded coherers was found to contain minute bubbles after reaction. The author exposed a particularly clean cut 0·019 mm. wide to waves without powder. A number of small sparks were seen to play between the edges, and the interval became covered with a fine brown deposit. The tinfoil appeared somewhat frayed. This experiment makes it very probable that in some cases, at all events, the reaction of the coherer is a purely electrical process. E. E. F.

1364. *Applications of the Coherer.* **O. Leppin.** (Annal. Phys. Chem. 65. 4. pp. 885–889, 1898.)—The author confirms Auerbach's observations concerning the influence of sound-waves upon the resistance of coherers. The influence depends upon the pitch of the sound. The Branly coherer used contained copper filings. It was placed in the focal line of the Hertzian mirror. Of some twenty organ-pipes, only one produced a deflection; but this deflection was not less than that due to electric waves, and was obtained even at a distance of 20 m. At some distances the deflection failed, and experiments proved that in those cases the coherer was situated at a node. The coherer also acts as a microphone and as an indicator of heat- and light-waves. The experiments quoted are, however, not conclusive for proving that light operates except by its heating effects. E. E. F.

1365. *Oscillatory Currents.* **E. F. Northrup.** (Elect. World, 31. pp. 674–676 & 710–711, 1898.) [See Abstract 946.]—The special application of the author's high-frequency apparatus to Röntgen-ray work is considered; and a method is described of regulating the vacuum of Röntgen-ray tubes, and hence the penetrative power of the rays given off by them. Some of the more striking phenomena of high-frequency currents are next described, more particularly those illustrating the enormous importance of impedance as against simple resistance. The powerful electromagnetic and electrostatic induction-effects due

to high-frequency currents are next illustrated by some experiments, and their application to a system of wireless telegraphy tried by the author is explained. A. H.

1366. *Measurement of Phase-difference.* **A. G. Rossi.** (Écl. Électr. 15. pp. 322–333, 1898.) [See Abstract No. 797.]—Besides the method involving the use of a pencil of kathode rays, the author suggests the use of a light metallic spherical shell suspended at the centre of the system of conductors (shown in fig. 2, Abstract 797). In general, before any adjustment has been attempted, the resultant field is an elliptic one. Now such a field may be regarded as due to the superposition of a simple alternating field whose direction is that of the major axis of the ellipse on a rotating circular field whose intensity is proportional to the minor axis. Since a simple alternating field exerts no couple on a conducting spherical shell, it follows that the maximum couple will be obtained when the resultant field is circular. Accordingly the angles ψ_1 and ψ_2 must be adjusted until the conducting shell gives the maximum deflection. This method would not, however, in many cases be of sufficient delicacy. A small test-coil, of a sufficiently large number of turns, may then be placed at the centre of the conductors and connected to an extremely sensitive electrodynamometer (one of the Bellati type). The author describes a special form of apparatus designed for use with such a search-coil, and by means of which the adjustments required for the determination of the phase-difference may be made in a rapid and systematic way. Finally, the author considers the condition of equilibrium of the movable portions of the conductors in fig. 2 when these are delicately suspended or pivoted, and from this deduces another method of arriving at the phase-difference. A. H.

1367. *Electromagnetic Screening.* **L. Arons.** (Annal. Phys. Chem. 65. 3. pp. 590–594, 1898.)—Gives the elementary treatment of a simple case of electromagnetic screening, in which the influence of the changed conductivity of a neighbouring conductor and the difference in behaviour during periodic and aperiodic change of the magnetic field are embodied in manageable formulæ. E. E. F.

1368. *Magnetic Tests by d'Arsonval Ballistic Galvanometer.* **S. Sheldon** and **T. Cocks.** (Elect. World, 31. p. 735, 1898.) —The authors first investigate the throw per microcoulomb of a d'Arsonval ballistic galvanometer of 1030 ohms resistance and 11 seconds period with various resistances in the external circuit. They find the throw varies from 80 divisions to 132, as the external resistance is increased from zero to 10,000 ohms. If the calibration of the galvanometer is made by the earth-inductor method the standard solenoid method, or the time of oscillation

and logarithmic decrement method, the resistance external to the galvanometer can be easily made of any magnitude. If the calibration be made by the much more convenient standard cell and condenser method, it is necessary to make use of a double-tongued key or equivalent device. Such a key has an upper and lower contact. In operation it charges a standard condenser from a standard cell, discharges it through the galvanometer, and then immediately closes the galvanometer through a resistance that can be adjusted at pleasure. To prove experimentally that concordant results would be obtained irrespective of the resistance of the galvanometer-circuit, so long as the corresponding constants were employed, a test ring was subjected to a constant magnetising force of such a magnitude as to bring the induction up to the knee. The magnetising current was reversed, and the induction calculated from the throw. This was repeated with various resistances from 0 to 10,000 ohms in the galvanometer circuit; the values for the induction agree within the limits of experimental error. A further test was made by measuring the hysteretic constant of a sample of iron known to have considerable hysteresis; by obtaining the B-H curve in the usual manner, the value obtained was $\eta = 0{\cdot}0039$. η was also measured by the wattmeter method, using a wattmeter, a Cardew voltmeter, and a Hartmann & Braun hot wire ammeter. The result obtained was $\eta = 0{\cdot}0043$. The authors consider the difference between these two values as probably due to a viscous hysteresis or magnetic creeping which goes on during the interval between the successive observations of the step-by-step process. This would make the area of the hysteresis-loop smaller than if the cycle were accomplished in a fraction of a second. The authors conclude that the results obtained from a d'Arsonval ballistic galvanometer, when properly manipulated, are to be relied on. Furthermore, a d'Arsonval galvanometer which is quite heavily damped, which is of low resistance, and which has a time of oscillation as small as one second, can be made to give accurate results. E. C. R.

1369. *Electromagnet for High Induction.* **P. Weiss.** (Écl. Électr. 15. pp. 481–487, 1898.)—The magnet is in the form of a rectangle, of which three sides are formed of a single piece of forged iron, the middle part being cylindrical and of 7 cm. diameter and 32 cm. long. In the side parts slide two cylindrical cores of the same diameter; they are threaded at their external ends, and can be moved either way independently of one another by means of two small bronze wheels forming nuts on them, working similarly to the poppet of a lathe. The cylindrical cores can be fitted with various pole-pieces, either flat or truncated cones. The coils are carried by the movable cores, and the side of the rectangle parallel to them, the bobbin covering the latter consisting of 2200 turns of wire 2 mm. in diameter. The cores have each a bobbin of 600 turns, between which there remains a free space of 9 cm. Two supplementary bobbins of 200 turns

each can be placed in this space over the poles. The bobbins will carry a current of 9 amperes for 2 hours, or 14 amperes for 10 minutes without over-heating, giving, with the supplementary coils, 32,000 and 50,000 ampere-turns respectively. The total resistance is about 9 ohms, and for the maximum current requires 125 volts and absorbs 1·75 kilowatts. With conical pole-pieces (the half-angle at the apex of the cone being $63\frac{1}{2}°$), truncated to a diameter of 1 cm., placed 5 mm. apart,—

Current =	2·7 amperes.	H = 19,000
	8·9 ,,	26,000
	11·7 ,,	26,600
	14·3 ,,	27,300

With a current of 11·4 amperes, the same pole-pieces give

Distance apart.	
5 mm.	H = 26,500
3·5 ,, ...	29,500
2 ,, ...	30,500

E. C. R.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

1370. *Companions of Argon.* **W. Ramsay** and **M. W. Travers.** (Roy. Soc. Proc. 62. pp. 316–324, & 63. pp. 437–440, 1898.)—In earlier papers (C. R. 123. p. 214, mentioned in Phys Soc. Abstracts, No. 779, 1896, and Roy. Soc. Proc. 60. p. 206), a description was given of attempts to separate argon and helium into portions of different densities by diffusion,—when they met with partial success only in the case of helium. In the first of the present papers a figure and description is given of a larger and improved apparatus. In the case of air as a test, a fairly rapid separation of O_2 and N_2 was effected. Nitrogen prepared from ammonium chloride proved to be homogeneous as regards the relative density of its individual molecules. Helium from samarskite and cleveite was subjected to a very large number of fractionations. Small quantities of nitrogen and of argon were separated, but no unknown gas. It is incidentally mentioned that helium is inodorous and tasteless, has a density of 1·98, a refractivity of 0·1238, and a probable atomic weight of 4.

In the second paper argon is re-investigated by fractional distillation. Eighteen litres were prepared from air by absorbing the O_2 by copper and the N_2 by magnesium. By means of liquid air boiling under reduced pressure, 13 to 14 litres were liquefied in a small bulb. A considerable quantity of a *solid* was seen to separate in the liquid and round the sides. By exhaustion two fractions, forming 50 or 60 c.c. of gas, were distilled into gasometers; the density was found to be 17·2. The first fraction was mixed with O_2 and sparked over soda. After removal of the O_2 by phosphorus, the density of the residual gas was 14·67, and the spectrum showed, with other lines, a brilliant yellow one of wave-length 5849·6; therefore not identical with those of sodium, helium, or krypton. Unlike these elements it was rapidly absorbed by the red-hot aluminium electrodes of a vacuum-tube, and the appearance changes as the pressure falls from fiery red to a most brilliant orange, which is seen in no other gas. The name *neon* is proposed. Its position in the periodic table would require a density of 10 or 11, which may probably be reached by further fractionation.

The remaining argon was now distilled off, and the jacket removed. On slightly raising the temperature the solid was seen to melt, and was distilled into a separate gasholder. Its density was found to be 19·87. The spectrum was very complex and differed entirely from that of argon. The measurements are given. Its wave-length for sound proves it to be monatomic. The authors propose the name "metargon." Krypton did not appear in the higher boiling fraction. S. R.

1371. *Krypton.* **W. Ramsay** and **M. W. Travers.** (Roy. Soc. Proc. 63. pp. 405–408, 1898.)—750 c.c. of liquid air were allowed to evaporate slowly, till 10 c.c. were left. This residue was distilled into a gas-holder: after removal of O_2 and N_2, and after sparking with O_2 over soda, 26·2 c.c. were left of a gas almost free from argon and showing a new spectrum with two very brilliant lines almost identical with D_3. The specific gravity is 22·47. The wave-length of sound shows it to be monatomic.

S. R.

1372. *Helium, Argon, and Krypton in the Periodic System.* **W. Crookes.** (Roy. Soc. Proc. 63. pp. 408–411, 1898.)—Some years ago the author constructed a model illustrating in three dimensions his rearrangement of the periodic table. The present paper describes and figures a new edition of the model (founded on a "figure of eight") which includes the recently discovered elements, about whose position there has been so much difficulty. Electro-positive elements are disposed on one side of the figure, negative on the other, valency is governed by distance from centre, and other properties depend similarly on position. S. R.

1373. *Ionisation by the Boiling-point Method.* **H. C. Jones** and **S. H. King.** (Chem. News, 77. pp. 243–244, 1898, and American Chemical Journal, 19. no. 9.)—The authors draw attention to the value of the boiling-point method for the determination of ionisation in solvents having but small ionising power. This method has not been much used owing to want of accuracy. The authors have obtained good results by using a modified Beckmann apparatus in which the thermometer is surrounded by a platinum cylinder: this cuts off radiation and prevents the condensed solvent from coming in contact with the thermometer until it has been reheated. Results are given for potassium iodide and sodium acetate in alcohol. W. R. C.

1374. *Molecular Weights by Vapour Pressures.* **W. R. Orndorff** and **H. G. Carrell.** (Journ. Phys. Chem. 1. pp. 753–759, 1897.)—The authors used the method of Will and Bredig, but discarded their water-bath. Although by so doing variations of temperature amounting to several degrees were sometimes introduced, the results were found to be equally good. Passing the air through the solvent first, and then through the solution, was not found to be so successful as the reverse method. Certain details, which are described, should be attended to in order to ensure success. Bulbs, though plugged, were found to lose over 10 milligrammes in twenty-four hours; the time of an experiment should therefore be reduced as far as possible. The results are generally found to vary with the rate at which the air is passed, and there is one rate which is the best. In calculating the results the formula $M=46gs'/100s$

was used, in which M is the molecular weight, g the weight in grammes of solute in 100 of the solvent, s the loss in the solvent bulbs, s' that in the solution bulbs, and 46 is the molecular weight of alcohol used as solvent. The results vary considerably in value. For urea (mol. wt. 60) under various conditions the figures obtained were 55, 46, 62, 51, and 70. W. R. C.

1375. *Molecular Depression of Freezing-point.* **M. Wildermann.** (Zeitschr. Phys. Chem. 25. 4. pp. 699–721, 1898: see also Transactions of the Chem. Society, 1897.)—The author has determined the molecular depression of the freezing-point of water produced by acetone, aniline, dextrose, and phenol. The method used is that described previously. The convergence temperature is below the freezing-point of the solution, and different parts of the scale of the thermometer (graduated to $\frac{1}{1000}°$) are used, giving mean differences of 1 or 2 %. Further results are also given for several other substances, tabulated below:—

Substance.	Molecular depression.
Acetone	1·82 to 1·85
Aniline	1·83 to 1·85
Phenol	1·82 to 1·83
Dextrose	1·85 to 1·87
Urea	1·87 to 1·89
Maltose	1·84
Milk-sugar	1·85 to 1·88

A further set of determinations of the freezing-points of solutions containing urea and resorcinol, cane-sugar and urea, dextrose and urea, and alcohol and urea, shows that the law that in very dilute solution each substance exercises its influence on the freezing-point independently of the other is true within the limits of experimental error. T. E.

1376. *Electric Osmosis and Electro-stenolysis.* **A. Coehn.** (Zeitschr. Phys. Chem. 25. 4. pp. 651–656, 1898.)—The author has shown (see Abstract No. 505, 1898) that bodies of higher dielectric capacity assume a positive charge in contact with bodies of lower dielectric capacity. The explanation of electrical osmosis given by Helmholtz assumes the formation of an electrical double-layer, one side of which is on the wall of the capillary passage (say a crack in a glass tube immersed in the liquid), the other on the liquid filling it. If the liquid is water, it will, owing to its high dielectric constant, be positively charged. If electrodes be placed, one within the glass tube, the other without it, the positive charge on the water in the crack will be displaced towards the negative electrode, leaving a negative charge on the glass. If the water contains a salt, say copper sulphate, in solution, the Cu ions will be drawn to the glass wall, their electrical charges neutralised and separated out in the metallic state. The SO_4 ions may be similarly

neutralised by the electrostatic positive charge on the water, giving dissolved oxygen and sulphuric acid. The very minute metallic deposit thus formed will act as an intermediate conductor with anodic and kathodic ends and can only increase to visible dimensions if—(*a*) the negative radicle separated at the anode does not dissolve the metal; (*b*) an insoluble substance separates at the anode; (*c*) the negative radicle combines with the salt in the solution. Salts which come under one or other of these headings should exhibit the phenomenon to which Braun has given the name of Electrostenolysis, namely, the deposition of a metallic or other deposit on the walls of a fine crack in a glass wall which is placed between two electrodes in the solution of an electrolyte. A critical survey of Braun's results shows that this conclusion is in the fullest agreement with the facts. T. E.

1377. *Diffusion through Gelatine.* **A. Hagenbach.** (Annal. Phys. Chem. 65. 4. pp. 673–706, 1898.)—Various gases are enclosed in a vessel under constant pressure which is separated from another vessel by a wooden plate containing a large number of holes filled with gelatine. The transfusion through the gelatine is used for determining the coefficients of diffusion of the gases. The amount in c.c. of the various gases traversing in one day a cube of 20 per cent. gelatine is 0·845 in the case of CO_2, 0·509 for N_2O, 0·0565 for H, 0·230 for O, and 1271 for ammonia, at 17° C. The vapour-tension of gelatine is about the same as that of water. The absorption of gases in gelatine is hardly different from that in water, but the diffusion-coefficients are smaller in gelatine. Exner's rule, according to which the volumes of gases exchanged are as the absorption-coefficients, and inversely proportional to the square roots of their densities, is only approximately verified. E. E. F.

1378. *Hydrolytic and Electrolytic Dissociation.* **G. Platner.** (Elektrochem. Ztschr. 5. pp. 23–27, 1898.)—The author considers the process of solution and its connection with electrolysis from the point of view of the chemist, and contrasts the conceptions of hydrolytic and electrolytic dissociation. We are indebted to electrolytic theories for the introduction of the idea of dissociation as affording an explanation of certain physical facts, but it is questionable whether this dissociation takes place exactly as supposed. Chemical facts are, it is claimed, in favour of the hypothesis of hydrolytic dissociation, with which the electrolytic theories should, by suitable modifications, be brought into agreement. J. W.

1379. *Electrolysis of Calcium Chloride Solutions.* **F. Oettel.** (Zeitschr. Elektrochem. 5. pp. 1–5, 1898.)—Experiments made by the author some years ago, the publication of which has been delayed, are in full accordance with the results of Foerster and

Bischoff (see Abstract No. 830). The formation of a membrane of precipitated lime round the kathode is confirmed, and its efficiency is stated to be independent of its thickness. An attempt was made to devise a continuous process by adding potassium chloride to an electrolysed solution of calcium chloride, then separating the sparingly soluble potassium chlorate, and again submitting the regenerated calcium chloride to electrolysis. It was found, however, that the presence of potassium chloride in the solution caused the precipitation of hard, thick crusts of lime with simultaneous liberation of free chlorine. This may sometimes be remedied by addition of free lime, but the effect of this is very variable. By cooling an electrolysed solution of calcium chloride, long, hard needles of an oxychloride of calcium were obtained, and it is supposed that this substance may play an important part in the process. Accidental contamination of the electrolyte with salts of copper from the connections was found to cause decomposition of the hypochlorite, with evolution of oxygen. Oxides of iron, copper, lead, nickel, and, as is well-known, cobalt, have the same prejudicial effect. The author considers electrolytic formation of chlorates to take place in two ways: (1) by conversion of the hypochlorite first formed into chlorate; (2) by direct combination of chlorine and oxygen during their simultaneous liberation at the anode. The first reaction predominates in neutral, and the second in alkaline solutions. J. W.

1380. *Most Economical Current in Electrolysis.* **Vogel.** (Écl. Électr. 16. p. 116; from 'Theorie elektrolytischer Vorgänge,' pp. 109, 110).

If i_0 = current density per sq. metre;
q = superficial area of anode or kathode in sq. metres;
i = the intensity of the current;

then $$i = i_0 q.$$

If l = distance separating the electrodes in centimetres;
a = spec. resistance of the electrolyte;
r = resistance of the cell, neglecting that of the electrodes;

then $$r = \alpha \frac{l}{q \times 104}.$$

If e = back E.M.F. of the cell;
t = number of working hours per year;
T = work performed;

then $$T = i(e + ir)t \text{ or } i_0 q t(e + i_0 \alpha l).$$

If g = the electrochemical equivalent of the body deposited, the weight deposited in one year will be $= git$ or gi_0qt, and the work required to deposit unit weight of the substance will be

$$= \frac{T}{gi_0qt} \text{ or } \frac{1}{g}(e + i_0 \alpha l).$$

If P=the cost of a unit of electrical energy delivered at the terminals of the cell, the cost of the energy requisite to deposit unit weight of the substance will be

$$\frac{P}{g}(e+i_0 al). \quad \text{(I)}$$

The cost of the electrolytic cell may be taken as proportional to the superficial area (q) of the electrodes, and to the price (n) of 1 c.cm. of the kathode material. If K be taken to represent the frequency of renewal of the cell and its electrodes, then the amount expended under this head will be $=nq\times K$ per annum, and the expenditure upon maintenance per unit weight of the substance deposited will be

$$\frac{nqK}{gi_0 qt} \quad \text{(II)} \qquad \text{or} \qquad \frac{nK}{i_0 gt}.$$

The most economical deposition evidently occurs when the sum of the expressions (I) and (II) is a minimum amount. This obtains when

$$i_0=\sqrt{\frac{nK}{Ptal}}.$$

[*Abstractor's Note.*—The 104 in the second equation is obviously a misprint for $(10)^4$, and on this account all the succeeding equations are vitiated.] J. B. C. K.

1381. *Electrolytic Refining of Tin and Treatment of Tin Ores.* **S. Cowper-Coles.** (Elect. Engin. 22. pp. 81–82, 1898.)—This article gives a description of various processes that have been tried from time to time for the electrolytic refining of tin, and also for the recovery of tin from its ores. The process of Claus, which consists in using an electrolyte of stannate of sodium or sulpho-stannate of sodium, is given as one of the most successful methods for the electrolytic refining of crude tin. Dr. Burghardt's, Classen's, Vortman & Spitzer's, and other electrolytic processes which have been experimented with for the recovery of tin from its ores, are also briefly described. Author.

1382. *Ashcroft Process for Treatment of Broken Hill Sulphide Ores.* **E. A. Ashcroft.** (Electrician, 41. pp. 554–558, 1898.)—An abstract of the paper read by the author before the Institute of Mining and Metallurgy in June. The paper deals with the trial runs of the Ashcroft process at Cockle Creek, N.S.W., in 1897 and 1898, and with the causes that had led to the failure of the process (see also Abstract No. 687). A very large number of figures were given bearing upon the costs of the thirteen separate operations incidental to the carrying out of the process. The three chief causes of failure were:—

1. Falling off in the metal contents of the ore sent to the electrolytic works for treatment by the Ashcroft process.
2. Inability to make the process truly cyclic, owing to the accumulation of manganese and other impurities in the electrolyte.
3. Lack of the funds necessary for carrying out the process upon the scale for which the plant had been designed.

The author believes that the second of these might be obviated by the adoption of a new method of treatment which he has worked out and patented, and that a profit could be earned even with the poorer ores, by working the electrolytic process in conjunction with this "oxide process" at Cockle Creek. The latter process consists in separating the zinc in the form of basic zinc sulphate from the impure electrolyte, and in roasting this to obtain zinc oxide, which is then retorted in the usual manner, in order to obtain the metal. Whereas the first hundred tons of zinc recovered at Cockle Creek cost £75 per ton, and the second hundred tons £28 per ton, the author states that with a plant designed for working the conjoint process upon the scale of 1000 tons ore per week, he could obtain a profit of 20*s.* 3*d.* per ton of ore treated, equal to £50,000 per annum profit upon a capital outlay of £250,000. J. B. C. K.

1383. *Electrolytic Extraction of Metals.* **D. Tommasi.** (Electrician, 41. pp. 591–594, 1898.)—An illustrated description of the Tommasi electrolyser. This consists of a rectangular tank, containing a circular kathode disc, revolving between two fixed anodes. The disc is only half immersed in the electrolyte; and its upper part passes between two scrapers, which serve to depolarise its surface, and also to remove the deposits of metal when spongy. When the metal is deposited in coherent form upon the kathode, a disc with removable segments is used, and the kathode is stripped by immersing any segment with its deposit, in a bath of the molten metal. The anodes may be in the form of metal plates; or coarse powder packed in perforated receptacles may be used as anode material. A detailed account of the application of this electrolyser to the desilverisation of argentiferous lead is then given. The electrolyte used consists of a mixture of lead acetate with acetate of sodium or potassium, and of some undivulged compounds in addition. Cast anodes of the argentiferous lead are used. The revolving disc may be of aluminium bronze, nickelled iron, copper, or sheet iron. It should be 3 metres in diameter, and make 1–2 revolutions per minute. The deposit will be spongy in character, and may be removed by the scrapers at intervals. The detached lead sponge is washed, pressed, and melted with 2–3 % carbon in order to obtain it in ingot form. The silver remains behind as a sludge on the bottom of the electrolyser. Theoretically no appreciable E.M.F. should be required to transfer the lead from the anode to the kathode. Practically ·75 volt is requisite. Calculations are given by the author which show that

with a plant producing 25,000–30,000 tons of lead per year of 300 working days, the cost per ton with steam-power would not exceed 8·60 francs, and with water-power would not exceed 5·80 francs. Adding all incidental charges, the cost per ton should not exceed 10 francs, whereas the cost of the usual refining process is stated by the author to be 30 francs per ton. The spongy lead, instead of being melted down into ingots, may be used directly for (1) accumulator plates, (2) the manufacture of massicot, litharge, or minium, (3) the manufacture of lead carbonate. According to the author all these products can be produced much more cheaply from the electrolytic lead sponge obtained in his process than by the present processes of manufacture. J. B. C. K.

GENERAL ELECTRICAL ENGINEERING.

1384. *Rowbotham Primary Battery.* (Elect. Engin. 22. pp. 139–142, 1898.)—The electrodes are carbon and iron, and the electrolyte a mixture of diluted sulphuric and nitric acid. The cell consists of two compartments, one open and the other closed. The open one contains the iron plates. The closed one consists partly of porous tubes containing the carbons in the form of rods. Water surrounds the iron plates, while the acid mixture is admitted to the closed compartments. Enough acid passes through to allow of voltaic action taking place, though not enough, it is said, to cause local action. When a current is generated gas is evolved at the carbons, and pressure is exerted in the closed compartment, thus forcing more acid into the iron compartment. On cutting off the current water flows through the iron compartment and removes the acid, thus preventing local action on standing. In a report by S. P. Thompson the cost of current is estimated at $6\frac{1}{4}d.$ per B. T. U., excluding depreciation, interest on prime cost, and superintendence. H. T. Harrison puts the cost at $5d.$ The writer of the article disputes these figures and estimates the cost at $15{\cdot}77d.$ W. R. C.

1385. *Silver Chloride Dry Cells.* (Elect. Engin. N. Y. 26. pp. 47–48, 1898.)—A description of dry cells suitable for testing, made by the Chloride of Silver Dry Cell Battery Co. W. R. C.

1386. *Application of Storage Batteries.* **J. Appleton.** (Elect. Rev. 43. pp. 353–354 & pp. 391–393, 1898.)—The saving effected in lighting and power stations by the introduction of storage batteries to take the peak of the load is discussed and the point illustrated by a description of the plant installed for running the Buffalo-street Tramways from Niagara Falls. Particulars are given of a battery claimed to be 50 °/₀ larger than any other in the world, recently installed at Chicago. It consists of 166 cells capable of giving 12,000 amperes for 1 hour. Data are also furnished of a number of motor-cars driven by accumulators, and the arrangements of a charging station in New York for electric cabs are described.
E. J. W.

1387. *Lightning and Lightning Arresters.* **H. E. Raymond.** (Elect. World, 31. pp. 713–715 & pp. 772–775, 1898.)—In these articles the author differs from Mr. Wurts, and thinks that frequently arresters of the short-gap type having a resistance in series are of more value than the non-arcing metal type. An arrester ought to act at a voltage not much greater than the working-line voltage. The gap ought to be as short as possible, but such that the current cannot follow a discharge. No swinging, fuse blowing, or mechanical devices should be used to effect this. In installing, one arrester at least should be placed so as to receive

the crest of any wave liable to reach the generators, and another set placed so as to obtain the benefit derived from the natural impedance of any length of wire. A lightning arrester affords but little protection from a direct "stroke." W. G. R.

1388. *Lightning Arresters.* **A. J. Wurts.** (Elect. World, 32. pp. 5–6, 1898.)—There are two types of lightning arresters dealt with here, one using a spark-gap and a resistance in series with it, the other several spark-gaps without any resistance in series. The author is of opinion that spark-gaps without resistance in series should be used on account of the suddenness of a lightning discharge. The Fire Underwriters' rules require that lightning arresters must be connected with a thoroughly good and permanent ground connection by metallic strips or wires having a conductivity not less than that of the No. 6 B. & S. wire, which must be run as nearly in a straight line as possible from the arrester to the earth-connection. Why then put a resistance in the arrester? W. G. R

1389. *Lightning and Lightning Arresters.* **H. E. Raymond.** (Elect. World, 32. p. 73, 1898.)—The author advocates the use of an overhead barbed wire for protection against direct lightning flashes from cloud to earth, since an enormous installation of station and line arresters would be required to adequately protect any system from the effects of a very heavy "main path" discharge in close proximity to the line. Arresters form sufficient protection against inductive discharges, but not against "main-path" discharges. W. G. R.

1390. *Switchboard Construction.* **A. B. Herrick.** (Amer. Electn. 10. pp. 251–254, 1898.)—This is an article on the practical construction of switchboards for high and low tension-work, and gives important information regarding the various details which tend to diminish risk of short circuits, etc. The author considers that in the construction of arc-light switchboards marble and slate should not be depended on, and the insulation at the various points of connection should be supplemented by micanite or built-up mica. W. G. R.

1391. *Underground Conductors.* **F. A. C. Perrine.** (Elect. World, 32. pp. 69–73, 1898; also 'Electrical Engineering,' July 1898.)—This is a descriptive and critical article on the methods of laying underground cables. The methods considered are:—(1) the solid or built-in system; (2) the draw-in and draw-out system; and (3) the trench system. W. G. R.

1392. *Insulation Resistance and Leakage Currents.* **A. Russell.** (Electrician, 41. pp. 206–208, 1898.)—If the two house-mains of an electric installation be denoted by A and B respectively, there

are three leakage-currents we have to measure:—(1) the direct leakage-current from the main A to "earth"; (2) the direct leakage-current from the main B to "earth"; and (3) the leakage-current between A and B which does not pass through "earth." If x, y, and a be the resistances of the paths of these currents respectively, then they can be easily determined as follows:—

(1) Measure the insulation-resistance of the main A to "earth" when B is earthed (X).

(2) Measure the insulation-resistance of the main B to "earth" when A is earthed (Y).

(3) Measure the insulation-resistance of the two mains in parallel to "earth" (F).

Then, obviously,

$$\frac{1}{x}+\frac{1}{a}=\frac{1}{X},$$

$$\frac{1}{y}+\frac{1}{a}=\frac{1}{Y},$$

$$\frac{1}{x}+\frac{1}{y}=\frac{1}{F},$$

which enable us to find x, y, and a; and hence, knowing the potential differences of the mains to earth, we can find the leakage-currents.

It is pointed out that, so far as danger from fire is concerned, it would be better to specify for a maximum permissible value for the leakage-watts rather than to fix minimum values for the various insulation-resistances. The author recommends that the leakage-watts should be measured (1) when all the switches in the house are turned off, and (2) when they are all on. He also gives a method of measuring the leakage-watts in a three-wire installation. It is proved algebraically that if F be the insulation-resistance of a three-wire distributing network, and V the potential difference between adjacent mains, then $\frac{V^2}{F}$ is the maximum possible value of the watts dissipated in earth-currents, and $\frac{V}{2F}$ is the maximum value of an earth-current. AUTHOR.

1393. *Ferrand Automatic Rheostat.* **M. Aliamet.** (Électricien, 15. pp. 337–338, 1898.)—A description is given of an automatic rheostat, the invention of J. Ferrand. A number of carbon rings are supported, in contact, upon a central insulating-rod, mounted in a frame. The mechanical pressure between the rings is adjusted by a series of levers and a variable counter-weight; the effect of the counter-weight may be diminished by an electromagnet. The electromagnet and the carbon-resistance are connected in series in the circuit where constant current is to be maintained; so that if the current tends to increase, the mechanical pressure between

the carbon rings is simultaneously relieved by the action of the electromagnet. Ferrand has used this apparatus with some success for keeping the current constant in a dynamo-shunt. R. A.

1394. *Metallic Resistances.* **E. K. Scott.** (Elect. Rev. 43. pp. 71–72, 107–108, & 187–188, 1898.)—Six tables are given in which are tabulated the resistance, size of mandril, length of wire in a given spiral, weight, price, etc., of German silver, platinoid, galvanised iron, manganin, Kruppin, Hadfield's "Resista," and Brunton's "Beacon" material. The sixth table gives particulars of resistance, weight, and price of expanded metal (iron). In practice it is stated as usual to wind the wire as a close coil spiral, and then pull it out to double the length, but the smaller sizes below No. 15 B.W.G. require drawing out rather more to give the necessary stiffness. The "Beacon" alloy, made by Messrs. Brunton & Son of the Musselburgh Iron Works, Scotland, is given as having a resistance about 48 times that of copper and a temperature-coefficient of ·007007.

Extra large resistance-frames, for use in testing etc., may be cheaply made of ordinary galvanised iron-wire netting folded up and down on a large wooden frame. Or a strip of netting, say 12 inches wide and 1-inch mesh, may be wound round and round from the centre outwards, adjacent layers being spaced about 3 inches apart by means of $\frac{3}{4}$-inch diameter iron rods at the four corners of each convolution. The resistance of iron-wire netting, No. 20 B.W.G. 1-inch mesh and 12 inches wide, is given as ·005 ohm per yard of length, and the safe current with good ventilation may be as high as 90 to 100 amperes. Three designs for resistance-frames are illustrated, and also a diagram showing the distance apart of supports for wire spirals of various diameters It is stated to be mistaken policy to skimp the ironwork of resistance-frames, as the extra metal gives mechanical stiffness and materially assists the cooling. In America, grids made of cast iron have been used as resistances with success. The Siemens iron tube resistances, the "packed card" and tramcar rheostats of the General Electric Co. (U.S.A.), and the Carpenter and Stewart Electrical Syndicates' enamel resistances are described. With regard to these enamel rheostats, it is stated that, without reckoning in the area of the radiating ribs, the Carpenter type will dissipate continuously 5 watts per square inch of overall plate area; thus the size 10 inches square will dissipate 500 watts. AUTHOR.

1395. *Gas Power.* **J. E. Dowson.** (Mech. Eng. 1. pp. 703–704, 1898.)—Practically the gas-engine trade began with the four-stroke cycle engine patented by Otto in May, 1876. From 1877 up to the end of 1897, the British and German makers sold 61,370 Otto engines, giving a total of 508,025 brake horse-power. The early engines had a compression of about 35 lbs., whereas the larger ones now compress to 100 lbs. per square inch before ignition; and the consumption of gas has been reduced from 32 cubic feet per brake

H.P. hour to about half that quantity. Engines are now built to indicate 220 H.P. each, and in one installation at Blackpool the gas-engines work regularly to 940 indicated H.P.

When town gas costs 3*s.* per 1000 cubic feet, the working cost of a gas-engine indicating 20 H.P. exceeds that of a steam-engine of the same power. Hence in 1878 the writer introduced a plant for producing cheap fuel-gas, which was tried in a Crossley engine in 1879. Results are given of trials made of the gas-power electric-light station at Leyton in 1896 and 1897. Four "Premier" gas-engines, of Wells Brothers, each giving 55 brake H.P., are driven by Dowson gas. Total fuel consumed, anthracite and coke, 0·9 lb. per indicated and 1 lb. per brake H.P. hour, and 2 lbs. per Board of Trade unit sold. Total cost of fuel, labour, etc., per unit generated is $1\frac{1}{2}d.$

At Leicester 4 Crossley engines, each of 50 brake H.P., and 2 of 25 brake H.P. work with Dowson gas, and the total fuel consumed was reduced from 4·6 lbs. in 1895 to 3·03 lbs. per Board of Trade unit generated in 1897. At Halifax, 2 engines of 60 brake H.P. each drive dynamos, and use 1·01 lbs. of anthracite per indicated H.P. hour, and 1·92 lbs. per electric unit generated. Other instances go to show that the consumption of fuel in gas-engines with Dowson gas is much less than in the best type of steam-engine. Anthracite peas can be used, costing 6*s.* to 7*s.* a ton at the pit, and nuts and cobbles cost 5*s.* to 6*s.* a ton more, yet with care the peas can give rather better gas. Good clean coke also makes Dowson gas.

Ludwig Mond has a large plant producing fuel-gas from bituminous coal or slack, chiefly for the recovery of ammonium sulphate. Some of the gas is used for heating furnaces, and the rest for driving gas-engines. Each producer makes gas enough for 2000 indicated H.P. per hour, and must work continuously day and night. The plant is too large and costly for power purposes on a moderate scale.

The writer compares the repairs and maintenance of a gas-plant with that of a steam-boiler of the same power. In a Dowson gas-plant the firebars, hopper valve, and some of the brick lining of the generator, also coke in the scrubbers, have to be renewed occasionally, not oftener than once a year, besides painting of iron-work. The cost of repairs for plant varies with the size; between 100 and 500 indicated H.P. plant is about £4 to £14 per annum.

W. R.

1396. *Bending Heavy Rails.* (West. Electn. 23. pp. 29–30, 1898.)—This is a description of a bending machine designed by C. E. Moore, to bend 7-inch 90-lb. rails. The machine takes 12 H.P. to operate it, and curves a 90-lb. rail at the rate of 40 feet per minute. Formerly it required 9 men 4 hours to bend one 90-lb. rail. The cost of bending has been reduced from 13 cents. to 1 cent. per foot.

A. S.

DYNAMOS, MOTORS, AND TRANSFORMERS.

1397. *Sparkless Reversal in Dynamos.* **H. N. Allen.** (Instit. Elect. Engin. Journ. 27. pp. 209–238, 1898.)—The author gives a detailed account of measurements of the inductance of armature coils in different positions and under different conditions. The inductance was measured by (*a*) the alternating-current method; (*b*) the secohmmeter method; (*c*) using a search-coil connected with a ballistic galvanometer, and breaking a continuous current flowing through the coil under test. The measurements show, as might have been expected, that the apparent inductance diminishes with increase of frequency. An approximate method of calculating the inductance of a drum-armature coil is explained. The variation of flux through the pole-pieces in a running machine may be investigated by winding a coil on the pole-piece. The author finds that this variation of flux may sometimes be considerable, but that by properly adjusting the brushes it may be reduced to a very small amount. From certain theoretical considerations, as well as experimental results, he arrives at the conclusion that the magnitude of the reversing field is much less than it is generally supposed to be. A. H.

1398. *Commutation in Dynamos.* **P. Girault.** (Ind. Élect. 7. pp. 153–158, 202–206, 231–233, 250–253, 1898.)—This is an elaborate calculation on the effect of irregularities of either field-magnets or armature on sparking in dynamos. It is shown that small interpolar spaces are disadvantageous on account of the variations of the flux due to that armature-coil which is under commutation. The author thinks that carbon brushes are always more conducive to sparkless commutation than gauge-brushes. He is also of opinion that it is possible to make machines in which there will be reversal of current at the forward polar horns, and which will run sparklessly on account of the dragging of the armature flux by the armature itself for the coils under commutation, by employing a large neutral zone, sufficiently subdividing the armature, and using brushes whose resistances vary progressively. W. G. R.

1399. *Westinghouse Crane Motors.* (Elect. Engin. N. Y. 25. pp. 705–707, 1898.)—The Westinghouse Co. make dust-proof motors, both alternating and direct-current, for cranes. The direct-current motor is a four-pole machine, the yoke of the magnets forming a cylindrical case which is completely closed by end-plates through which the shaft projects. The brushes are attached to one of the end plates. The larger polyphase motors are started on a reduced voltage by a device called an autoconverter, by means of which it is possible to adjust a motor after installation, to have any desired starting torque within very wide limits. The

crane-motors are provided with a regulator by which the pressure is varied; this gives a starting torque which is about four times the torque which the motor can develop continuously at high speed. A 40-ton crane, at the Westinghouse Machine Co.'s works, has two 20 H.P. alternating motors for the main hoist, one 10 H.P. for auxiliary hoist, two 5 H.P. for trolley travel, and one 20 H.P. for bridge-travel. R. B. R.

1400. *Polyphase Asynchronous Motors.* **W. G. Rhodes.** (Elect. Rev. 43. pp. 331–332, 1898.)—This is a descriptive account of the Boucherot system of polyphase motors in which the starting torque is increased by having two distinct stator windings, one of which can be rotated through an angular distance corresponding to half a period of the supply currents. The rotor is of the squirrel-cage type, and also has two circuits corresponding respectively to the two stator windings. AUTHOR.

1401. *Rotary Transformers.* **C. T. Child.** (Elect. Engin. N. Y. 25. pp. 608–609, 1898; see Abstract No. 986.)—The permissible output of a rotary transformer with a single winding depends not only upon its size, but on the nature of the supply current. It may be shown that the ratio of the copper losses in a rotary transformer to the corresponding losses if the machine were driven at the same output as a direct-current dynamo, is

$$\frac{8}{n^2 \sin^2 \frac{\pi}{n}} + 1 - \frac{16}{\pi^2} + \frac{4}{n} \tan^2 \beta,$$

where n is the number of rings on the alternating-current side of the transformer, and $\cos \beta$ the power-factor. From this it follows that for a rotary transformer of given size, the output would, in terms of its output as a direct-current dynamo, be as follows (assuming $\cos \beta = 1$):—

Single-phase.	Two-phase.	Three-phase.
0·85	1·64	1·34

It is thus evident that for a given output the 2-phase rotary may be made smaller than the 3-phase, and much smaller than the single-phase machine. As compared with the motor-dynamo combination, the rotary transformer possesses the great advantages of high efficiency, cheapness, and simplicity; it is self-starting on the alternating side, running up to synchronism without difficulty. Its disadvantages are the interdependence of the alternating and direct-current voltages and the very limited range of adjustment of the latter. But for railway or electrolytic work these disadvantages are not serious. A brief general description of Hutin and Leblanc's "panchahuteur" is next given; the extreme mechanical complexity of this form of rotary transformer is a serious

disadvantage. But its efficiency is very high, and the output for size and weight remarkably large.—Some account of phase-transformers is next given, the arrangement due to Ferraris and Arno for deriving polyphase from single-phase currents receiving special attention. A. H.

1402. *Transformer Regulation.* **A. R. Everest.** (Elect. Engin. N. Y. 25. pp. 736–738, 1898.)—The author states that the direct experimental determination of the drop occurring in transformers is an extremely difficult matter, and that it is preferable to calculate this quantity from the known values of the copper and iron losses and the drop due to leakage, all of which quantities may be determined by experiment without much difficulty. He then proceeds to explain, by means of clock-diagrams, how the calculation may be carried out, illustrating the method by a numerical example. A. H.

1403. *Transformer Construction.* (Elect. Engin. N. Y. 25. pp. 746–747, 1898.)—The paper contains an illustrated description of the two standard types of large transformers made by the General Electric Co., viz., the "air-blast" and "natural draught" types. The former type is designed for continuous operation, large output, and high potential. The primary and secondary coils are assembled in small intermixed groups, each separately and heavily insulated, with air-spaces between them. The coils are placed in a vertical position, the core-plates being horizontal. The latter are also divided into a number of sections, with horizontal air-spaces between them. Along the air-ducts so formed a cooling current of air is forced from below through two sets of paths at right angles to each other, the air passing vertically through the windings and horizontally through the core. The motor driving the blower absorbs an amount of power which seldom exceeds $\frac{1}{4}$ % of the transformer output, and frequently is not more than $\frac{1}{10}$ %. Such transformers are used on 15,000 volt circuits or under, but may also be constructed for higher potentials. The rise of temperature above the surroundings is guaranteed not to exceed 40° C. The "natural draught" type is designed so as to offer a very large cooling surface. It is, for transformers of large output, much more expensive than the air-blast type, but for moderate output the cost per kilowatt is about the same for both types. "Natural draught" transformers are built in sizes ranging from 5 to 200 kilowatts, the standard pressures being 10,000 volts for the primary, and 3120 or under for the secondary. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1404. *New Plant at Niagara Falls.* **O. E. Dunlap.** (Elect. Engin. N. Y. 26. pp. 73–75, 1898.)—The Niagara Falls Hydraulic Power and Manufacturing Co. have just placed in operation the first turbine and generator installed in the extension of their power-house. The addition to the building is 60 ft. long by 100 ft. wide, bringing the total dimensions of the power-house up to 120 ft. by 100 ft. A steel penstock about 11 ft. in diameter has been constructed to supply water for the new turbines; it extends horizontally out from the cliff for about 60 ft. and then vertically for about 200 ft., finally passing under the floor of the power house. The first of the five new turbines to be installed is of the Jonval-Geyelin improved type, consisting of two bronze wheels on a horizontal shaft contained in a heavy cast-iron casing: the total weight of the turbine is 21 tons, and it develops 2500 H.P. This wheel is to operate two alternate-current generators, one of which already supplies current to the National Electrolytic Co.

Aluminium has been used for the conductors from this generator to the works; from the power-house to the top of the bank these conductors are bracketted to the penstock, and consist of bars 25 ft. long and 6 in. by $\frac{1}{2}$ in. in cross-section, four being placed in parallel rivetted together; at the top of the bank each group of bars is connected to 12 aluminium cables rubber-insulated. The core of each cable is about $1\frac{1}{4}$ in. in diameter, composed of No. 10 wire. The total amount of aluminium in the conductors is about 22,000 lbs., the same work in copper would require about 48,000 lbs. The conductivity of the aluminium used as compared with copper of the same section is about 63 °/₀, but for the same weight it is more than double. Aluminium cables, although requiring more insulation, present many advantages, as the great strength and lightness of the material enable long spans to be used, reducing the number of poles and insulators required, while large cables can be handled and erected with ease and rapidity.

The paper contains a detailed description of the new turbines, alternators, switchboards, etc., and two views of the new penstock. M. G. W.

1405. *Power-Station at Toledo, Ohio.* **W. S. Smith.** (Elect. World, 31. pp 491–493, 1898.)—The author gives an account of the power-station recently erected by the Toledo Traction Company to meet the increased demands upon the power, traction, and lighting system controlled by this company. The chief point of interest is the arrangement of the generators. There is one Lake Erie engine of 1200 H.P. driving by belt one 6000-light Westinghouse alternator and one 5000-light G.E. alternator. Two 800 H.P. Porter-Allen tandem engines each carry on the

shaft two 200-kw. G.E. lighting generators for the three-wire system. Four 1200 H.P. Wheelock cross-compound engines each drive by means of ropes one section of a shaft 198 feet long. These four sections may be all connected by means of friction clutches. At each end of the shaft are connected two 100-kw. G.E. generators for the three-wire system, and between these are a number of rope-driven machines; the latter include seventeen arc-lighters, four alternators, one booster, and three generators for the power service. Besides driving this shaft, each Wheelock engine carries upon its shaft a 500-kw. G.E. generator, three of these being used for traction and the fourth as a reserve for traction and power service. Owing to the combined traction and lighting supply, a comparatively constant load results, and the arrangement of plant described enables the machinery to be run at a higher load than would be otherwise possible. The Lake Erie engine supplies the alternating incandescent load, and the Porter Allen engines the direct-current load during heavy demand. As the lighting load diminishes, it is taken by the auxiliary dynamos on the shaft, so that for the greater part of the day the whole load is taken by the traction plant. W. R. C.

1406. *Accumulator Tramway Traction.* **E. Hauswald.** (Écl. Électr. 15. pp. 536–543, 1898; abstract of a paper read before the Elektrotechnischer Verein, 25 Jan. 1898.)—The author, after making some general statements as to the desirable characteristics of a traction cell, refers to the Pollak cell, and states two experimental laws:—(1) A plate will only bear a high rate of discharge if the discharge amounts to a fraction of its normal capacity. (2) The higher the efficiency at which a plate is worked the longer is its life. Curves are given showing the variation of efficiency with rate of discharge and with the amount of discharge. The author calculates the power required to propel a car. The mean results obtained on the accumulator line at Frankfort show that the energy required per car-kilometre for an 8-ton car travelling at 15 kilometres per hour is as follows:—

	Watt-hours.
Without stops	180
With 3 stops, battery coupled in series at starting	320
With 3 stops, battery coupled in parallel at starting	260

It therefore appears that accumulator-cars can be run at 30 to 40 watt-hours per ton-kilometre, instead of 60, which is the generally accepted figure. Having regard to the above laws, the battery employed should be small, discharged to only a small extent and frequently recharged. This system is employed at Frankfort. The cars carry 42 passengers, but only weigh 8 tons, including a battery of 84 T_6 Pollak cells. A single motor of 15 H.P. is provided. The batteries are charged at the rate of two minutes per kilometre run, at constant pressure so that gassing does not take place; once a week they are charged up to 2·5 volts per cell. The battery efficiency amounts to 85 %. Such a system

is only suitable for short lines. When the distance exceeds the efficient limit, mixed traction may advantageously be employed, the trolley line being sufficiently long to give the requisite charge. The author also considers accumulator-traction for suburban railways.

Hopfelt remarked that the first above mentioned law applies to Faure, but not to Planté plates. W. R. C.

1407. *Cost of Electric Traction at Leeds.* (Railway World, 7. pp. 142–143, 1898.)—The cost of tramway traction at Leeds is discussed. The following figures were obtained for the week ending March 28 last, and may be considered as a fair average:—

Total receipts from 21 electric cars	£656 16*s*. 4*d*.
Total car-mileage	14,777
Receipts per car-mile	10·66*d*.
Expenses per car-mile (including depreciation, renewals, repairs, interest, and sinking-fund)	8·60*d*.
Surplus per car-mile	2·06*d*.

The working expenses per car-mile, with no allowance for depreciation or repairs, is made up as follows:—

Electric-car shed..................	·57*d*.
Generating station	·69*d*.
Management and office	·32*d*.
Electric engineers' salaries..............	·13*d*.
Wages of drivers and conductors	1·84*d*.
	3·55*d*.

The energy used per car-mile amounted to 0·960 unit, and the cost of generation was 0·72*d*. per unit. The interest charged appears to be at the rate of $2\frac{3}{4}$ per cent. on the Corporation Loan; the sinking-fund is at $2\frac{1}{4}$ per cent. Depreciation, renewals, and repairs are all included in a sum of $7\frac{1}{2}$ per cent. on the capital. W. R. C.

1408. *Equipment and Maintenance of Tram-cars.* **M. S. Hopkins.** (Elect. World, 32. pp. 284–285, 1898: abstract of a paper read before the American Street Railway Association, Boston, Sept. 1898.)—The author discusses car-bodies, trucks, and electrical equipment; and then passes on to the question of maintenance. The paper scarcely admits of a short abstract. W. R. C.

1409. *Eddy Electric Carriage Motor.* (Elect. Engin. N.Y. 26. pp. 83–84, 1898.)—The results of a Prony-brake test of an Eddy carriage motor are given in curves showing speed, torque, and efficiency. A motor for driving a two-seated carriage weighing 1800 lbs. at 12 miles per hour on good macadam roads weighs 128 lbs., and will stand a maximum load much in excess of its average load. E. H. C.-H.

1410. *G.E. Narrow-Gauge Traction Motor.* (Street Rly. Journ. 14. pp. 459–460, 1898.)—A fairly detailed description is given of the new G.E 58 narrow-gauge motor of 37 H.P., designed for a minimum guage of 1 metre. The weight complete, with gear and gear-case, is 2150 lbs. W. R. C.

1411. *High-Speed Traction Motor for Suburban Service.* (Street Rly. Rev. 8. pp. 465–466, 1898, and Elect. Engin. N.Y. 25. pp. 720–721, 1898.)—The new type of General Electric Company's high-speed motor, known as G.E. 51-B, is illustrated and described. The capacity of these motors is 80 H.P., based on a rating of 75° C. rise in temperature of the windings above that of the surrounding atmosphere after an hour's run at rated load. A double equipment of these motors will propel a 20-ton car at a maximum speed of 26 m. p. h. on a level, with the gear-ratio of 2·27. Mounted on 33″ wheels, the clearance below the bottom of the frame is 3 inches. E. H. C.-H.

1412. *Trolley Line Construction.* **D. Pepper,** jun. (Frank. Instit. Journ. 146. pp. 55–62, 1898.)—Description is given of the chief points in construction of modern line-work. The limitations of the overhead trolley are stated to be 150 amperes, and 10 miles per hour. E. H. C.-H.

1413. *Sectional Conductor Electric Tramways.* **G. T. Hanchett.** (Elect. World, 31. pp. 494–497, 554–555, 586–587, & 645–648, 1898.)—The author gives a critical account of a number of sectional conductor systems. But no names are given, and no reference to actual trials of any system. W. R. C.

1414. *Street Lighting.* **H. Hopkins.** (Elect. Engin. N. Y. 25. pp. 731–733, 1898.)—The author briefly compares electric-arc lighting with other systems as regards reliability, cost, etc., and gives illustrations showing arc lamps in position. A. H. A.

1415. *Arc-Lighting Plant driven by Polyphase Motors.* (Amer. Electn. 10. pp. 239–244, 1898.)—A description is given of the arc-lighting plant of Brooklyn, U.S.A., which is now driven by three-phase synchronous motors in place of the steam-engines formerly used. Each motor is supplied at 6000 volts from the Union Station, and drives two 120-light Brush machines through flexible couplings; the motors are self-starting, with rotating field-magnets and ball bearings. A full description of the construction of the arc-light machines is given, with illustrations. Each 240-light unit occupies a floor-space of about 20 ft. × 5 ft. A large storage battery is installed, with transformers and rotary converters, and is able in case of need to maintain the supply not only to the low-pressure mains, but also, by reversing the rotary converters, to the polyphase motors driving the arc-lighters.

A. H. A.

1416. *Dick's System of Train-Lighting.* (Zeitschr. Elektrotechn., Wien, 16. pp. 321–327, 1898.)—A detailed description, with a sketch of the electrical connections, of Dick's system of train-lighting. Each carriage is provided with a battery of 57 small secondary cells, capable of giving a current of 3 amperes for over 8 hours. The batteries are joined in parallel across main conductors running the entire length of the train, connection between neighbouring carriages being established by means of flexible conductors. A single 12-H.P. dynamo, mounted after the manner of a tramway motor, so as to be driven off the carriage-axle by toothed gearing, is used for either charging the cells or supplying the lamps direct, in which case the cells act as regulators. An elaborate array of electromagnets controls the various automatic switching arrangements, the required constancy of E.M.F. with variable train-speed being obtained by throwing more or less resistance into the field-circuit. The only hand control is that of a simple two-way switch attached to each carriage, in one position of which the lamps are on and in the other off. A. H.

1417. *Richter's Electric Miner's Lamp.* (Électricien, 15. pp. 275-277, 1898.)—This is an accumulator lamp, and the improvements relate more particularly to the box and fittings. The box is provided on opposite sides with terminal sockets of different sizes for charging, these sockets being connected by double plugs; the ends of these plugs are of different diameters, to correspond with the sockets, so that the batteries can be readily coupled up in series for charging without risk of any of the batteries being connected up in the reverse direction. Some drawings are given in the paper, but the description is not very full. The lamp weighs 3 kilos, burns 10 hours, and gives 3 c.p. C. K. F.

1418. *Repairable Incandescent Lamps.* **C. Howard.** (Électricien, 15. pp. 280–281, 1898.)—In this lamp the platinum leading-in wires are provided with internal extensions of nickel wire, the ends of which fit into small sleeves or sockets; and into the other ends of these sleeves fit nickel wires bearing the filament and connected by a bridge-piece of glass. The neck of the lamp is extended to receive the sleeves and nickel wires, and is provided with ribs and a flange to prevent turning and lateral displacement of the lamp in its cap. To replace a filament, the neck of the lamp is cut near the middle of its length, the nickel wires bearing the filament removed from the sleeves or sockets, and a new filament with its nickel wires placed in position; the filament and its supports can then be inserted into the bulb, the lamp sealed up and exhausted. It is estimated that all the operations between the opening of the lamp and its replacement in working order cost less than 0·09 franc (0·865*d.*). C. K. F.

TELEGRAPHY AND TELEPHONY.

1419. *Cable Relay.* **K. Gulstad.** (Elect. Rev. 42. pp. 792–794, 1898.)—The author concludes his description of the vibrating relay referred to in Abstract No. 1007, and elaborates the method of working a cable on such a system. By means of curves of potential he seeks to show that, in general, the interference of the "sent" signals brings the vibrations of the relay-tongue into unison, and practically into synchronism with the reversals of the transmitter, in such a way that, while the transmitter sends a positive impulse into the cable, the relay sends a negative impulse into the cable at the receiving end, as well as into the third branch of the "T." The effect of varying the receiving- and adjusting-condensers is illustrated by recorder "slip." It is claimed that by the use of a vibrating relay the distortion of signals on undisturbed lines may be nearly eliminated, by adjustments similar to those applied in duplex working; and it is suggested that a vibrating relay might be used with actual duplex. Using an artificial cable a speed of 90 words per minute, with a "KR" of 700,000, has been attained, presumably with auto-sending. On the Newcastle-Gothenburg cable (KR=580,000), by this system, 110 words per minute have been sent from Newcastle and translated at Gothenburg to Nystad in Finland. On this cable a modification of the vibrating relay, due to Falck, gives 65 words per minute. In conclusion the author expresses an opinion in favour of increasing the currents used for working cables. R. A.

1420. *Wireless Telegraphy and Electromagnetic Waves.* **Della Riccia.** (Bull. Ass. Ing. El., Liège, 9. pp. 95–155, 1898.)—Describes Marconi's apparatus, and explains the nature and properties of electromagnetic waves. J. L. H.

1421. *Photo-Telegraphy.* (Elekt. Runds. 15. pp. 232–233, 1898.)—In 1887 Hertz showed that if the spark-gap of an induction-coil is widened just beyond the ordinary limits of sparking, a spark can be forced across it if a beam of ultra-violet light is directed into the gap. Zickler, of Brünn, now proposes to utilise this for the purpose of space-telegraphy. At the sending station an arc-lamp is provided with a shutter apparatus and a suitable lens or mirror for directing flashes towards the receiving station. The light of the arc is very rich in ultra-violet rays; it is therefore able to cause a spark to pass at the gap of an induction-coil at the distant end, and thus to affect a coherer-circuit. Signals have been transmitted in this manner through 200 metres, using an arc-lamp taking 25 amperes at 54 volts, and concentrating the light by a quartz lens 4 cm. in diameter. R. A.

1422. *Automatic Telephone Exchanges.* (Electrician, 41. pp. 52–53, 1898.)—Describes the apparatus of "The Direct Telephone Exchange Syndicate, Limited." Two lines are necessary for each subscriber, and in addition either an earth-return or, preferably, a return wire common to all subscribers. The subscriber's instrument is provided with a disc in which are holes numbered 0 to 9. The calling subscriber selects the successive figures of the required subscriber's number and operates the disc for each figure. He then turns the handle of his magneto-bell. If the connection is made, his bell rings. If the required number is already engaged, his bell does not ring. The operation of the disc first makes a combination circuit from one or other of the lines with the common return, and secondly sends a number of current impulses over the selected circuit.

In the central office mechanism, an insulated segment of impregnated plaster-of-Paris has placed upon it 100 contacts in 10 columns of 10 rows, each contact representing one subscriber to the exchange. A "wiper" connected to a movable shaft travels over the segment and is brought into position over the particular contact required by means of the combination lines and the current-impulses transmitted over them from the calling subscriber's instrument. Mechanism is provided whereby a connection to an already engaged line is prevented. At the central office each subscriber's line is provided with the selective apparatus upon which each line is "multipled" twice—first, for connection purposes and secondly for preventing connection in case of engagement. In exchanges exceeding 400 lines a supplementary automatic switch is necessary for each subscriber.

J. E. K.

1423. *Telephones on Toll System.* **H. P. Clausen.** (West. Electn. 23. p. 162, 1898.)—Summary of methods of calling attention. M. O'G.

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* Asterisk means Author.

NAME INDEX.

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